

AD-A054744

AFFDL-TR-77-79, Vol II

Flaw Growth in Complex Structure

Volume II – Test Data

Lockheed-California Company
A Division of Lockheed Corporation
Burbank, California 91520

December 1977

Final Report May 1975 - September 1977

Distribution Statement

Approved for public release; distribution unlimited.

Prepared for
Air Force Flight Dynamics Laboratory
Air Force Systems Command
Wright-Patterson AFB, Ohio 45433

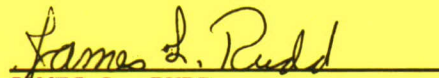
20070924242

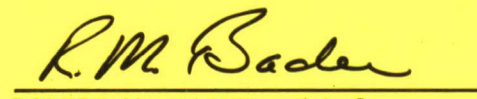
NOTICE

When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

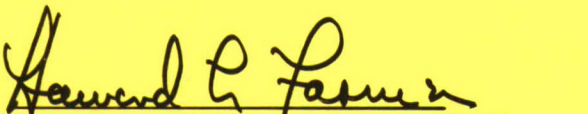
This report has been reviewed by the Information Office (IO) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.


JAMES L. RUDD
Project Engineer


ROBERT M. BADER, Chief
Structural Integrity Branch
Structural Mechanics Division

FOR THE COMMANDER


HOWARD L. FARMER, Colonel, USAF
Chief, Structural Mechanics Division

Copies of this report should not be returned unless return is required by security considerations, contractual obligations, or notice on a specific document.

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER AFFDL-TR-77-79, VOL II	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) FLAW GROWTH IN COMPLEX STRUCTURE FINAL REPORT, VOLUME II TEST DATA	5. TYPE OF REPORT Technical - Final Period Covered May 1975 - September 1977	
	6. PERFORMING ORG. REPORT NUMBER LR 28272 Vol. II	
7. AUTHOR(s) T. R. Brussat and S.T. Chiu, Lockheed-California Company, and M. Creager, Del West Engineering, Chatsworth, California	8. CONTRACT OR GRANT NUMBER(s) F33615-75-C-3093	
9. PERFORMING ORGANIZATION NAME AND ADDRESS LOCKHEED-CALIFORNIA COMPANY BURBANK, CALIFORNIA 91520	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 486U-02-09	
11. CONTROLLING OFFICE NAME AND ADDRESS Air Force Flight Dynamics Laboratory Air Force Systems Command, (FBE) Wright-Patterson AFB, Ohio 45433	12. REPORT DATE December 1977	
	13. NUMBER OF PAGES	
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASS. (of this report) UNCLASSIFIED	
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE	
16. DISTRIBUTION STATEMENT (of this Report)		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Fracture Mechanics, Fatigue, Structure, Testing, Damage Tolerance, Crack Propagation, Analysis, Crack Arrest, Spectrum Loading.		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The test data from Contract F33615-75-C-3093 "Flaw Growth in Complex Structure" are summarized in this volume of this report. Sixty-eight structural specimens (26 joints and 42 stringer-reinforced panels) were machined, precracked, assembled and fatigue tested. (Volume I is a detailed technical discussion of the program.) Data are tabulated for each specimen. Data plots are also presented in which the test results are compared to analytical predictions.		

FOREWORD

The experimental and analytical research program reported herein was the responsibility of the Structural Methods Group of the Lockheed-California Company from 12 May 1975 to 12 September 1977. The work was performed for the Air Force Flight Dynamics Laboratory to fulfill the objectives of Contract F33615-75-C-3093.

J. L. Rudd was the AFFDL technical monitor, and his continuous interest in every detail was of great technical benefit to the program.

The care that was taken in specimen preparation and testing led to a reliable set of test results. Specimen fabrication and precracking were coordinated by W. P. Renslen with assistance from W. F. Kerwin, both of Del West Engineering. Testing, under the direction of D. E. Pettit, was carried out by the Lockheed Rye Canyon Fatigue Laboratory personnel including F. M. Pickel, D. Black, C. J. Looper, L. Reed, L. Silvas and C. L. Spratt.

Special thanks are in order for W. G. Browne, who provided continuous guidance in budget management and program administration throughout the course of the program. E. K. Walker, J. C. Wordsworth, and J. C. Ekvall are thanked for their valuable contributions in the area of program management as well as their technical consultation. Others in the Stress Department who made significant technical contributions were L. Bakow, W. L. Rakness, P. Schall and R. C. Smith. R. J. Van Ness and the Publication Services Department are appreciated for coordinating the layout, typing and artwork for the final report.

TABLE OF CONTENTS

Section		Page
I	INTRODUCTION	1
II	BASELINE DATA	2
III	DOUBLE LAP JOINTS	8
IV	SINGLE LAP JOINTS	38
V	TEE REINFORCED CONTINUOUS SKIN SPECIMENS	65
VI	TEE-REINFORCED SPLIT SKIN SPECIMENS	91
VII	EDGE STRINGER SPECIMENS	123
VIII	TWO-BAY SPECIMENS	148
IX	SPECIMEN PRECRACKING DATA	156

LIST OF FIGURES

Figure		Page
1	Example of Notation: Cracking Sequence in Specimen 4.6A-5	9
2	Predicted Crack Growth Sequence, Single Lap Joint Specimens	39

SECTION I

INTRODUCTION

Sixty-eight fatigue tests were conducted of mechanically-fastened structural test specimens containing 0.050-inch fatigue-induced initial corner cracks. This volume contains a specimen-by-specimen summary of these test data. The data are presented on annotated tables giving crack sizes versus loading cycles. The data are plotted and compared to crack growth predictions, which were formulated prior to the testing as summarized in Section V of Volume I.

Because of the number of specimens tested and the complexity of each, an almost unlimited time could be spent reviewing and learning from the data. The purpose of Volume II is to provide an easy-to-read, concise, yet complete summary of each test result in the program, to facilitate future analytical review and use of the data by readers of the report.

SECTION II

BASELINE DATA

Baseline tensile data for the six product forms used in this program are presented in this section. In addition, R-curve data obtained using four center-cracked panels (CCT) are included. The R-curve data are presented in the form of stress intensity factors, K , versus incremental equivalent crack length, ΔC_e . The equivalent crack length, C_e , was calculated using crack opening displacements (COD) and Equation (50) in Volume I.

Other baseline data are tabulated or plotted in Section IV of Volume I.

TENSILE TEST RESULTS

PRODUCT FORM	SPECIMEN NUMBER	GRAIN DIRECTION	THICKNESS (INCH)	WIDTH (INCH)	TENSILE ULTIMATE (KSI)	TENSILE YIELD (KSI)	PERCENT ELONGATION
0.188 SHEET	N-1T	Trans.	0.1830	0.5030	87.5	76.7	13.0
	N-2T	Trans.	0.1827	0.5035	87.0	76.3	13.5
	N-3T	Trans.	0.1833	0.5030	87.2	76.6	13.0
	N-4L	Long.	0.1823	0.5020	85.2	78.6	14.0
	N-5L	Long.	0.1820	0.5017	85.4	78.6	14.5
	N-6L	Long.	0.1825	0.5023	85.1	78.5	14.0
0.094 SHEET	A-1L	Long.	0.0949	0.4973	83.5	77.3	12.5
	A-2L	Long.	0.0946	0.4977	83.9	77.9	13.0
	A-3L	Long.	0.0947	0.4985	83.5	77.1	13.0
	A-1T	Trans.	0.0948	0.4983	85.2	74.9	13.0
	A-2T	Trans.	0.0948	0.4985	85.2	73.7	13.0
	A-3T	Trans.	0.0948	0.4983	85.4	74.4	12.5
0.25 PLATE	B-1L	Long.	0.2557	0.5025	83.5	78.2	13.0
	B-2L	Long.	0.2554	0.4952	82.8	77.2	13.0
	B-3L	Long.	0.2556	0.4957	83.3	77.7	13.0
	B-1T	Trans.	0.2588	0.5010	84.4	73.6	13.0
	B-2T	Trans.	0.2587	0.5020	83.8	73.0	12.5
	B-3T	Trans.	0.2588	0.5018	84.1	72.0	13.0
0.375 PLATE	C-1L	Long.	0.386	0.5015	84.4	42.4*	14.0
	C-2L	Long.	0.3851	0.4997	84.4	79.6	14.0
	C-3L	Long.	0.3861	0.4995	84.0	78.1	13.5
	C-1T	Trans.	0.3858	0.4993	85.7	61.0*	12.0
	C-2T	Trans.	0.3858	0.5000	85.5	74.6	12.5
	C-3T	Trans.	0.3859	0.4994	85.6	75.2	10.0
0.25 ANGLE EXTRUSION	ANGLE-1L	Long.	0.2492	0.5000	89.3	61.9*	12.0
	ANGLE-2L	Long.	0.2473	0.4900	88.9	80.4	11.5
	ANGLE-3L	Long.	0.2495	0.4983	89.5	81.3	11.5
	ANGLE-1T	Trans.	0.0825	0.1280	83.4	75.3	13.0
	ANGLE-2T	Trans.	0.0823	0.1284	78.3	71.2	12.0
	ANGLE-3T	Trans.	0.0823	0.1288	79.0	70.7	12.0
0.188 TEE EXTRUSION	TEE-1L	Long.	0.1857	0.4993	88.4	80.8	9.5
	TEE-2L	Long.	0.1844	0.4983	87.8	80.3	11.0
	TEE-3L	Long.	0.1860	0.4983	87.9	80.7	11.0
	TEE-1T	Trans.	0.0805	0.1282	82.3	71.8	12.0
	TEE-2T	Trans.	0.0801	0.1287	79.7	71.7	12.0
	TEE-3T	Trans.	0.0795	0.1282	79.8	72.2	14.0

*Values not considered in computing average properties

R-CURVE DATA - SPECIMEN A-3-CCT

7075-T6, B = 0.0901 inch, w = 12.0 inch, A = 1.081 inch,

E = $10.4 \cdot 10^6$ psi, $2C_1 = 3.993$ inch

LOAD, p(kip)	COD (inch)	C _e (inch)	K (ksi √in.)	Δ C _e (inch)
19.2	0.0160	1.995	47.76	0
24.0	0.0207	2.06	60.97	0.065
26.0	0.0232	2.125	67.44	0.130
28.0	0.0257	2.18	73.89	0.185
28.4	0.0261	2.19	75.18	0.195
28.4	0.0271	2.25	76.60	0.255
29.0	0.0288	2.345	80.54	0.35
29.48	0.0298	2.375	82.62	0.38
29.48	0.0356	2.76	92.72	0.765
30.24	0.0372	2.82	96.82	0.825

$2C/w = 0.333$, $CEB_T = 0.71$, shift $0.781 - 0.71 = 0.071$

R-CURVE DATA - SPECIMEN B-3-CCT

7075-T6, B = 0.1825 inch, w = 12.0 inch, A = 2.190 inch,

E = $10.4 \cdot 10^6$ psi, $2C_1 = 4.005$ inch

LOAD, p(kip)	COD (inch)	C _e (inch)	K (ksi $\sqrt{\text{in.}}$)	ΔC_e (inch)
21.6	0.0089	2.00	26.57	0
30.0	0.0129	2.075	37.80	0.075
35.0	0.0152	2.105	44.53	0.105
40.0	0.0180	2.16	51.78	0.160
40.9	0.0157	2.195	53.53	0.195
42.0	0.0195	2.225	55.48	0.225
43.0	0.0204	2.27	57.60	0.27
44.0	0.0209	2.28	59.12	0.28
45.4	0.0219	2.30	61.38	0.30

NOTE: Two partial return slopes equal to measured $\frac{\text{COD}}{p}$ VOLUME ABOVE.

Pre-cracked $\frac{2C}{w} = 0.33$, CEB = 0.71, shift = $0.782 - 0.71 = 0.072$

R-CURVE DATA - SPECIMEN B-4-CCT

7075-T6, B = 0.183 inch, w = 12.0 inch, A = 2.196 inch,
 $E = 10.4 \cdot 10^6$ psi, $2C_i = 3.995$ inch

LOAD, p(kip)	COD (inch)	C_e (inch)	K (ksi $\sqrt{\text{in.}}$)	ΔC_e (inch)
25.0	0.0102	2.00	30.7	0
30.0	0.0127	2.07	37.6	0.07
35.0	0.0152	2.11	44.5	0.11
40.0	0.0180	2.17	51.8	0.17
41.0	0.0192	2.27	54.8	0.27
42.0	0.0198	2.28	56.3	0.28
42.5	0.0203	2.30	57.3	0.30
42.5	0.0210	2.345	58.2	0.345
43.0	0.0211			
44.0	0.0218	2.35	60.2	0.35

$$\frac{2C_i}{w} = 0.332, \text{ CEB} = 0.71, \text{ shift} = 0.778 - 0.71 = 0.068$$

NOTE: Slight buckling indication on partial unloadings.

R-CURVE DATA = SPECIMEN C-3-CCT

7075-T6, $B = 0.3862$ inch, $w = 12.0$ inch, $A = 4.634$ inch²,
 $E = 10.4 \cdot 10^6$ psi, $2C_1 = 4.00$ inch

LOAD, (kip)	COD (inch)	C_e (inch)	K (ksi $\sqrt{\text{in.}}$)	ΔC_e (inch)
48.0	0.0096	2.00	28.26	0
60.0	0.0126	2.10	36.20	0.10
70.0	0.0150	2.12	42.44	0.12
74.0	0.0165	2.22	46.13	0.22
78.0	0.0179	2.27	49.38	0.27
80.0	0.0189	2.33	51.59	0.33
82	0.0200	2.40	54.02	0.40
84	0.0212	2.52	57.38	0.52
86.3	0.0233	2.64	61.10	0.64

Precracked $\frac{2C_1}{w} = 0.333$, CEB = 0.71, shift $0.803 - 0.71 = 0.093$.

SECTION III

DOUBLE LAP JOINTS

The following pages present tabulated crack length versus number of cycles data for the fourteen precracked double lap joint specimens along with a graphic presentation of the crack path shown on face-to-face pages to facilitate cross reference. Specimens 4.6A-1 through 4.6A-10 are thick double lap joint specimens, and 4.6B-1 through 4.6B-4 are thin double lap joint specimens. The initial damage conditions for each specimen* were listed in Table 2 of Volume I. The applied cyclic stress was $S_{\max} = 17 \text{ ksi}$, $R = 0.1$.*

On the following data tables, the notation is as follows. In the double lap joint specimens the fasteners are numbered 1 through 6 in the precracked row (Row 2) and 7 through 12 in Row 3, where some secondary cracking often occurred. Side "A" is the fastener-head side of the specimen and Side "B" is the collar side. Thus a_{34} is the length of a crack on the head side of the specimen originating at Fastener Hole 3 and growing toward Hole 4, while b_{12-11} is the length of a crack on the collar side, originating at Hole 12 and growing toward Hole 11.

In some cases cracking occurred at the outermost fastener hole and grew toward the free edge. In this instance, the notation "E" is used to denote the edge of the specimen. Thus a_{7E} is the length of a crack in the skin originating at Fastener Hole 7 and growing toward the edge of the specimen. Crack lengths are in inches as measured from the edge of the hole on the visible outer surface.

In other cases fretting cracks occur away from the fastener holes. A fretting crack on the head side of a double lap joint specimen, originating between fastener Rows 2 and 3 directly above Fastener 4 is labeled " a_{F4} " and the length is simply the total length as measured on the visible surface.

To further clarify the notation a sequence of sketches is given for Specimen 4.6A-5 showing how the damage developed in this specimen.

*Except for Specimens 4.6A-9 and -10 which were identical to Specimens 4.6A-3 and -4 but were Phase II spectrum tested with a reference maximum spectrum stress of 30 ksi.

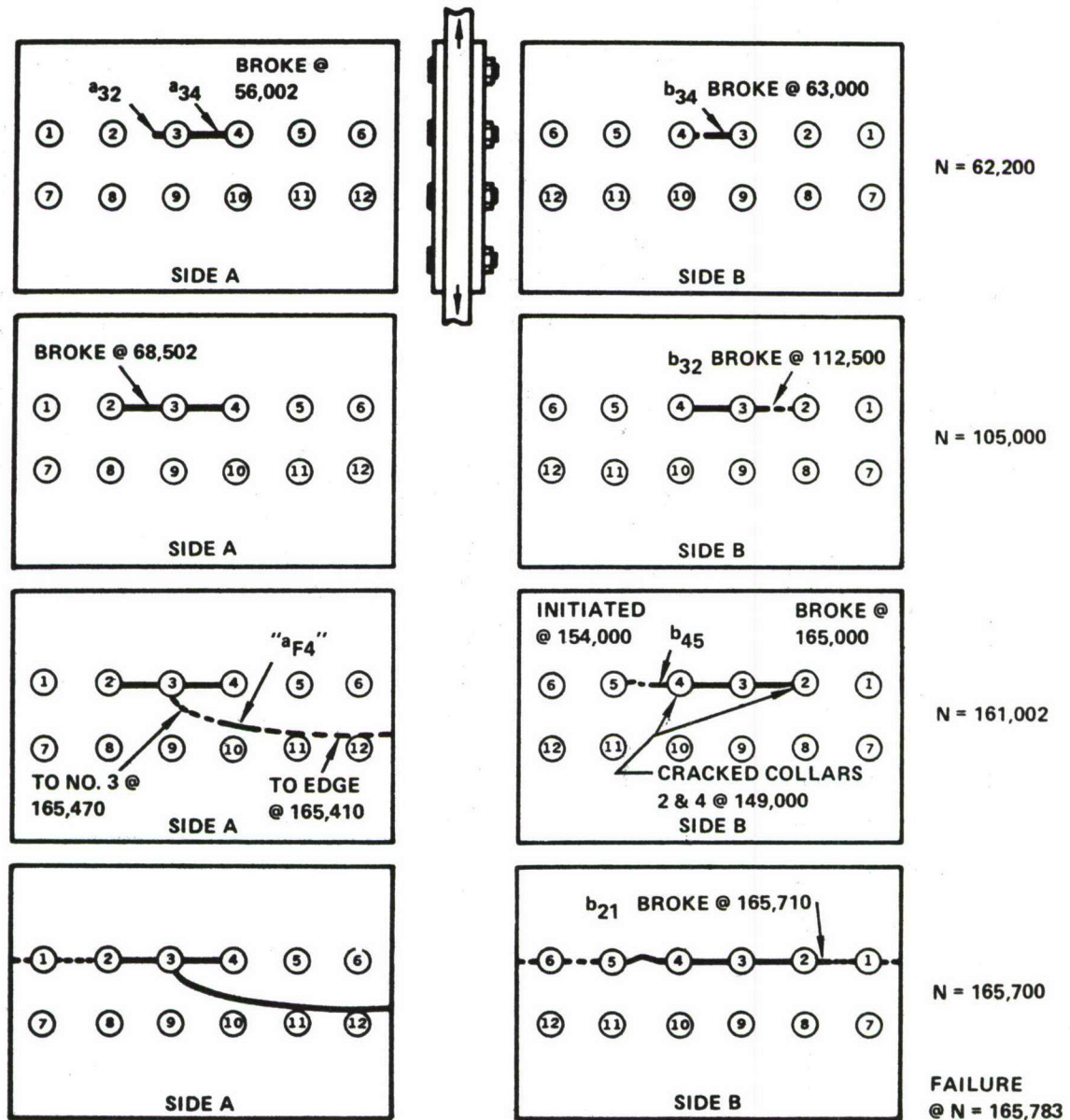
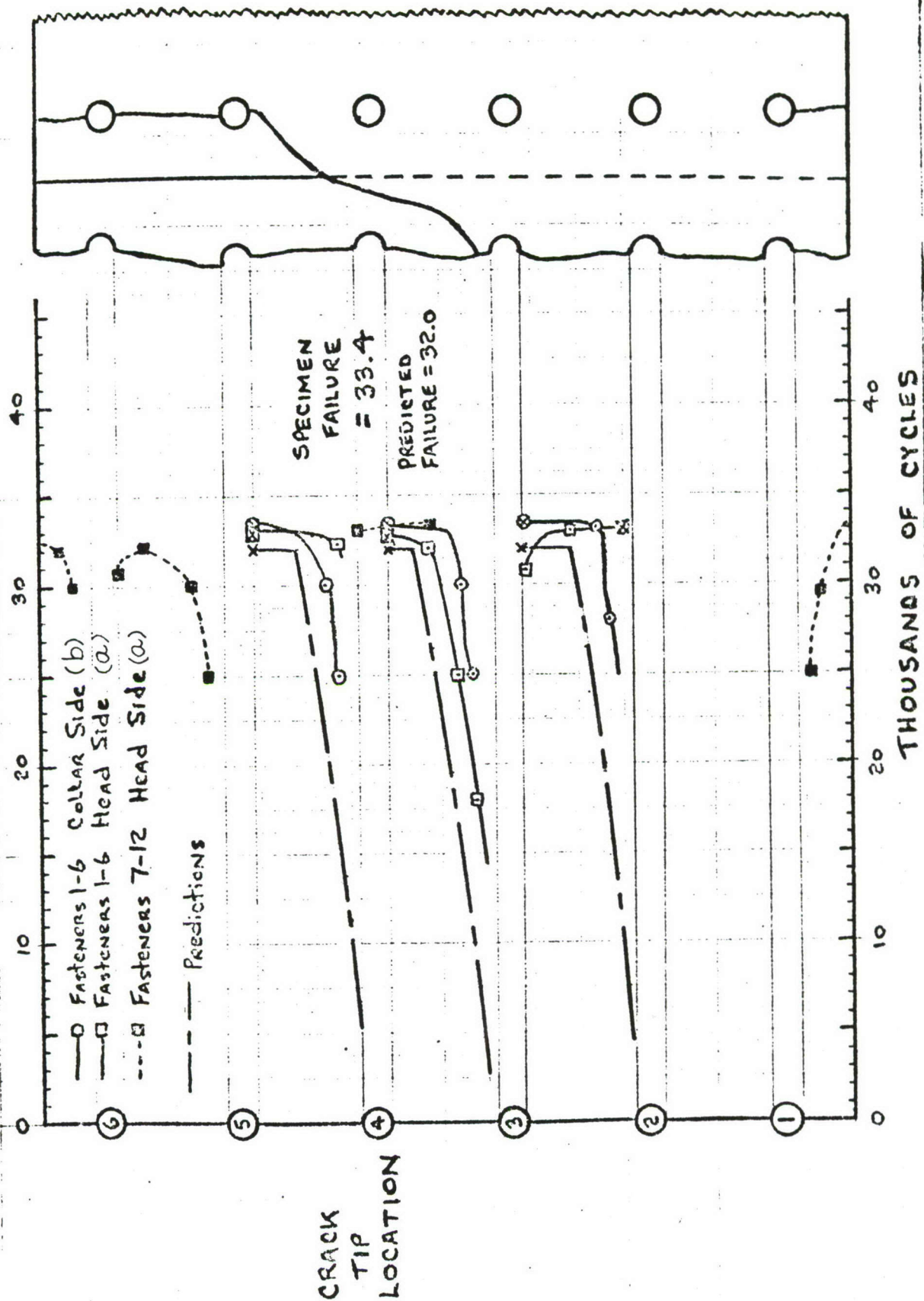


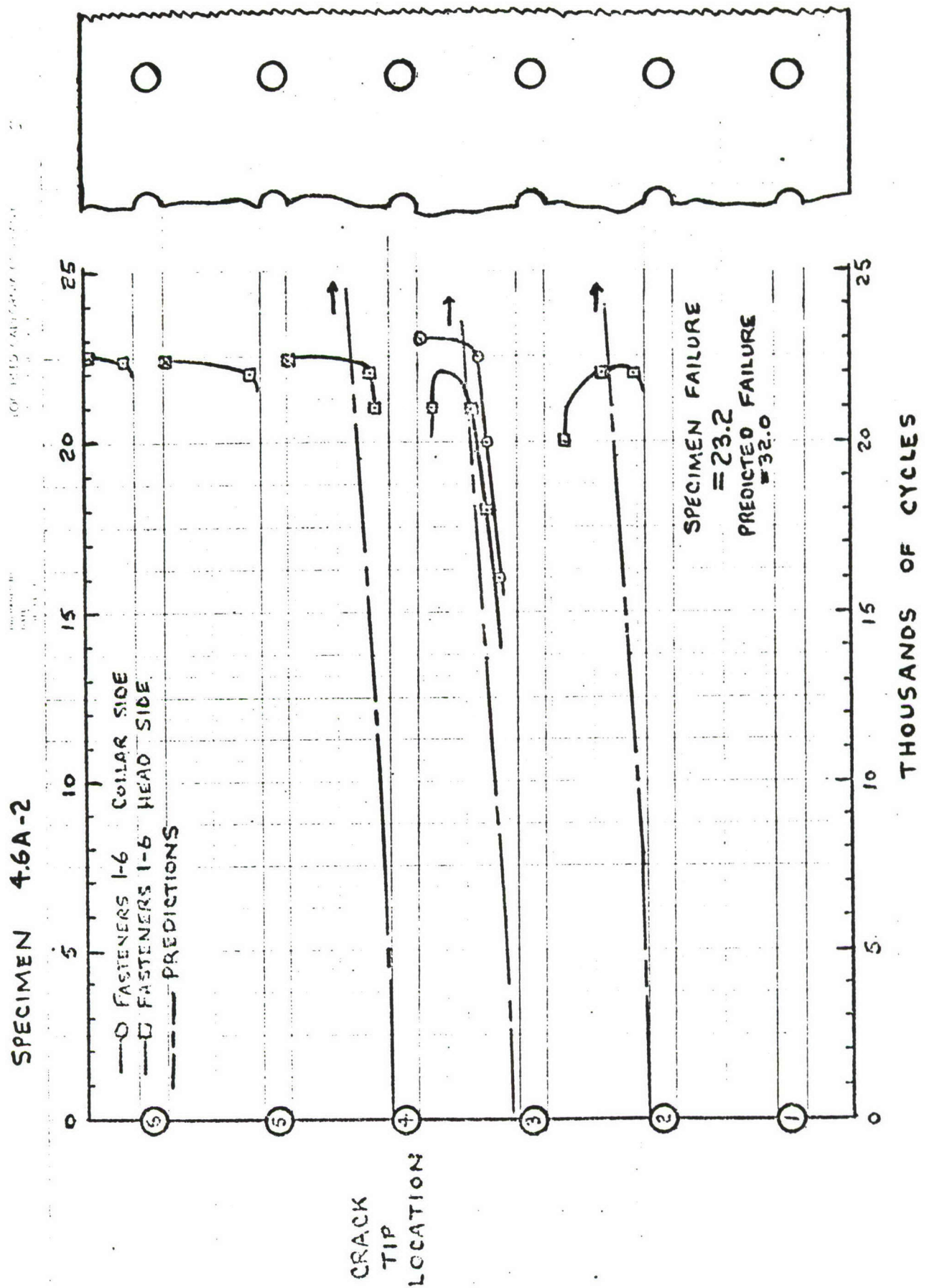
Figure 1. Example of Notation: Cracking Sequence in Specimen 4.6A-5

SPECIMEN 4.6A-1



SPECIMEN 4.6A-1

N	a _{7E}	a ₂₃	a ₃₂	a ₃₄	a ₄₅	a ₁₁₋₃	a ₁₁₋₁₂	a ₁₂₋₁₁	a _{12-E}	b ₂₃	b ₃₄	b ₄₅
I.C.		.005"		(.046)	.005"					.005"	(.047)	.005"
14500				.116								
16000				.157								
18000				.210								
20000				.260								
22000				.313								
25000	.160			.400			.197			.178	.263	.241
28000	.207			.506			.258			.251	.334	.316
30000	.293			.592			.375		.225	.308	.379	.365
32000	—			.740	.205		—	.260	.380			
32,300	.430			.770	.230		1.125 BROKE		.562 BROKE			
32715	—			.1125 BROKE	.420							
32800	.475				.670					.315	.495	.505
32820	—				1.125 BROKE					—	—	—
33003	.510		.500							.415	.525	.565
33075	.562 BROKE	—	1.125 BROKE									
33090						1.43						
33300						2.48				.575	1.125 BROKE	1.125 BROKE
33402						↓				1.125 @ 37400	↓	↓
												Failure



SPECIMEN 4.6A-2

N	a _{1E}	a ₂₁	a ₂₃	a ₃₂	a ₃₄	a ₄₃	a ₄₅	a ₅₆	a _{6E}	b ₂₃	b ₃₄	b ₄₅
IC												
14000					.197							
16000					.275						.215	
18000					.345						.254	
19000					.382						.315	
20000				.210	.453						.354	
21000				.218	.538	.157	.153				.396	
22000			.142	.642	.713	.205	.201				.429	
22042			—	—	1.125 BROKE THRU	—	—	.143			—	
22151			1.125 BROKE THRU	—	—	—	—	—			—	
22320			—	—	—	—	1.125 BROKE	1.125 BROKE	.138		—	
22358			—	—	—	—	—	—	.562 BROKE		.445	
22821		"DIMPLE"	—	—	—	—	—	—	—		.545	
22835	"DIMPLE"	1.125 BROKE	—	—	—	—	—	—	—		.595	
22920	—	—	—	—	—	—	—	—	—		—	
23037	.562 BROKE	—	—	—	—	—	—	—	—		.685	
23111	—	—	—	—	—	—	—	—	—		1.125 BROKE	1.125 BROKE
23243	—	—	—	—	—	—	—	—	—		—	—
23247	—	—	F	A	I	L	U	R	E		—	—

[illegible]

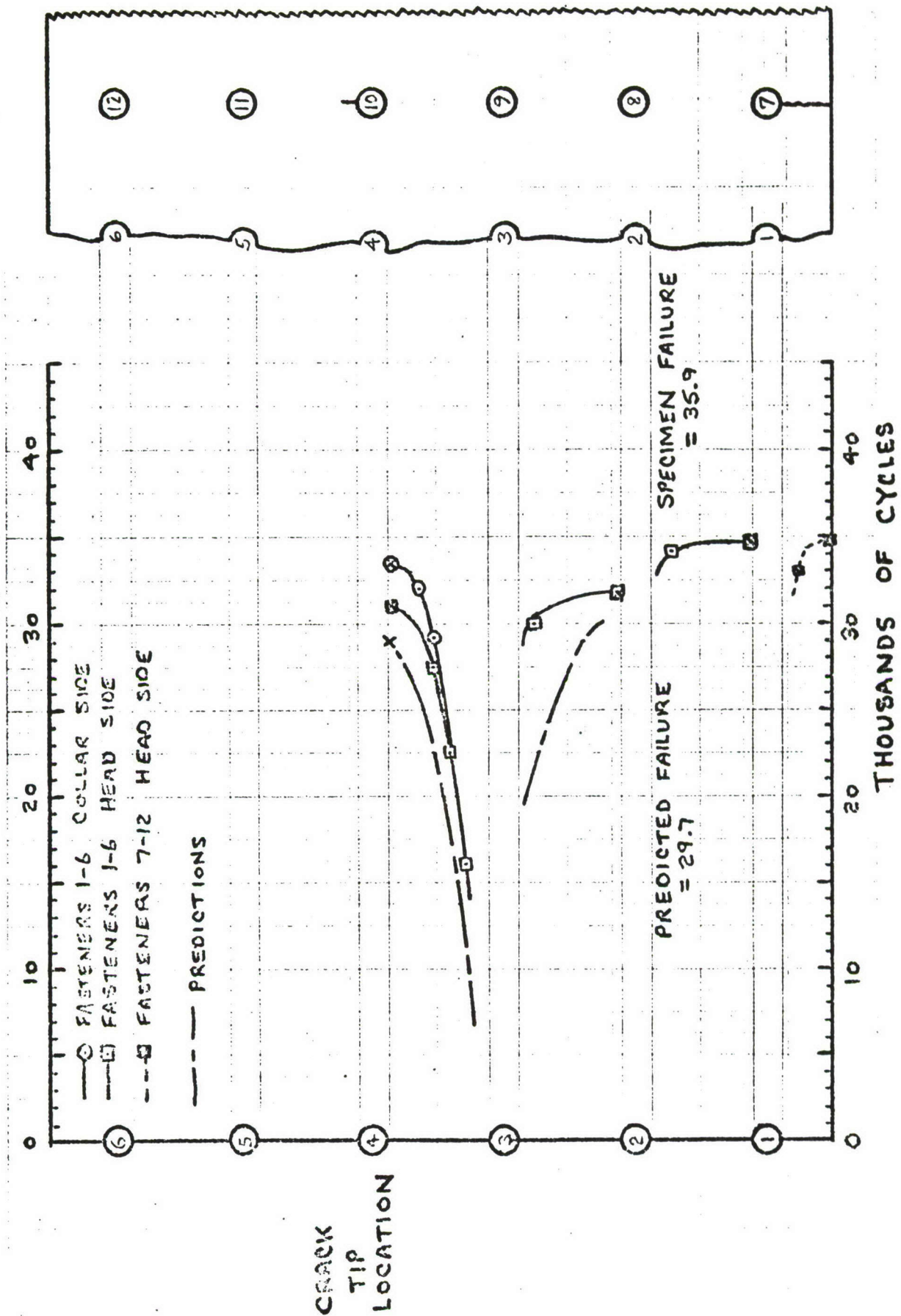
SPECIMEN 4.6A-3

N	a ₃₂	a ₃₄	b _{12E}	b ₁₂₋₄	b _{5C}	b ₄₅	b ₃₄	b ₃₂	b ₁₂	b _{1E}
41000							.253			
45000							.355			
50000		.111					.440			
55000		.167					.555			
60000		.254					.677			
65000		.293					.834			
67500		.323					1.003			
68000		.328					1.125 BRUCE			
74000		.430								
79000		.530						.183		
81000		.566						.279		
82000		.597						.349		
83000		.625						.445		
84000		.656						.543		
85000		.688						.659		
86000		.724						.858		
86340		—						1.125 BRUCE		
86700		—							.169	.150
88000		.816				.134			.305	.230
88929		—				—			—	.562 BRUCE
88969		—				1.125 BRUCE			1.125 BRUCE	
89000		1.125 BRUCE								
92000			.216							
92800			.293							
92854			.562 BRUCE							
92889				1.00						
92951				1.70						
93000	DIMPLE			—						
93078	1.125 BRUCE			2.00						
93200	↓	↓	↓	—	1.125 BRUCE	↓	↓	↓	↓	↓
93300	↓	↓	↓	2.00	↓	↓	↓	↓	↓	↓
93385	F	A	I	L	U	R	E			

SPECIMEN 4.6A-4

DATE: 11/1/60

TESTED BY: J. J. HARRIS



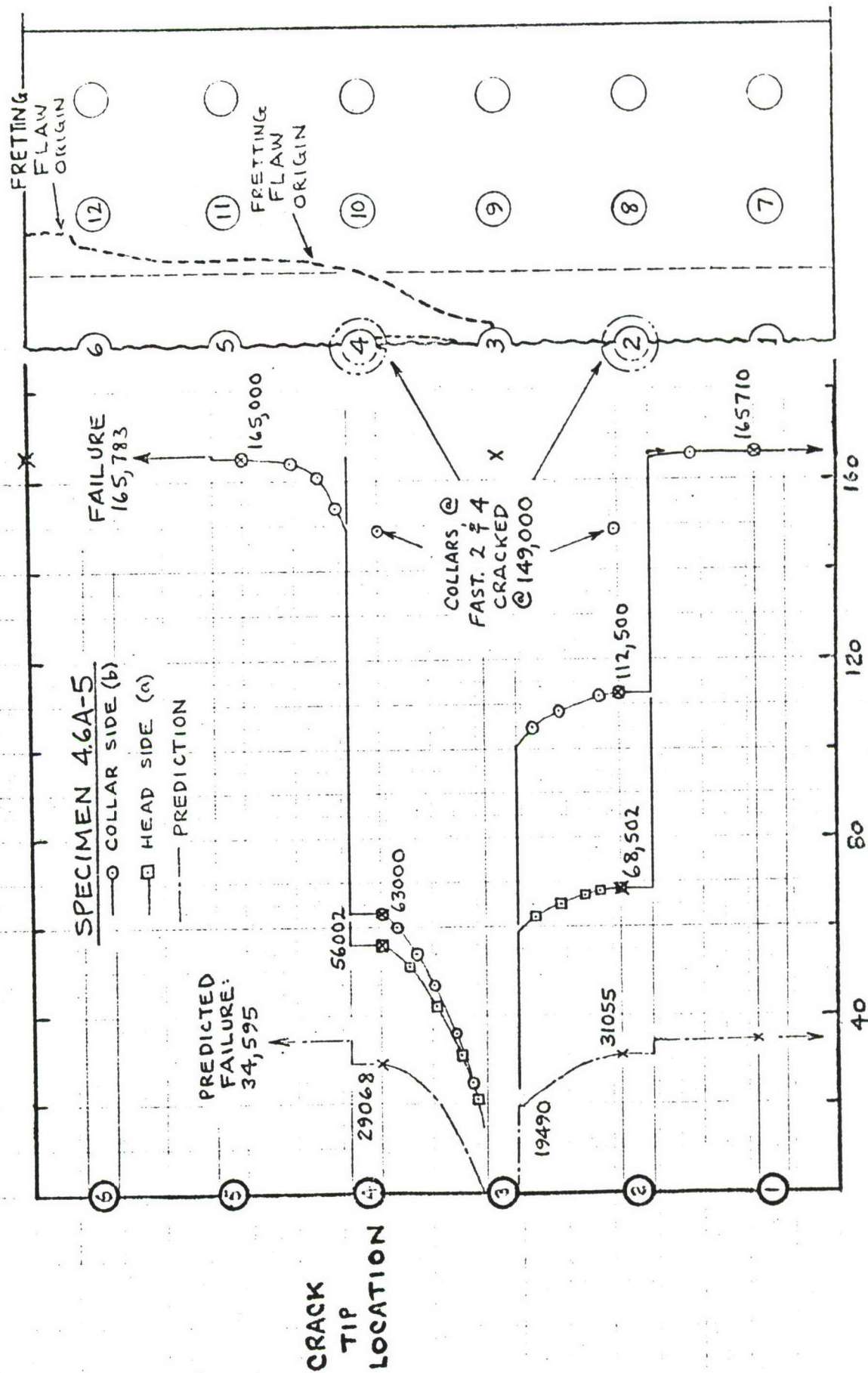
SPECIMEN 4.6A-4

[illegible]

SPECIMEN 4.6A-5

LOGGED CATEGORY 1

LOGGED CATEGORY 2



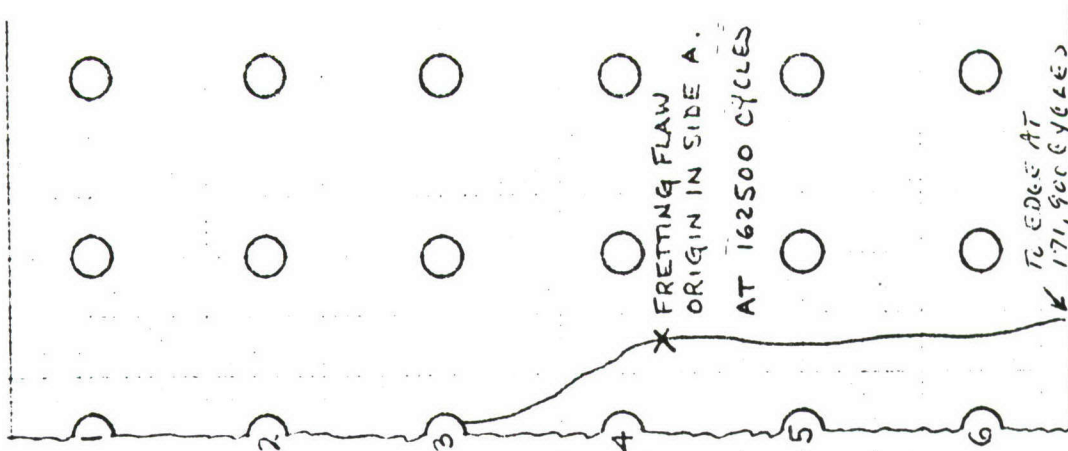
SPECIMEN 4.6A-5

N	a ₃₂	a ₃₄	"a _{F4} "	b ₄₅	COLLAR B4	b ₃₄	b ₃₂	COLLAR B2	b ₂₁
21000		.113							
25000		.190				.162			
30000		.281				.233			
36000		.392				.337			
42000		.547				.467			
47000		.690				.575			
51000		.845				.678			
54000		1.000				.769			
56002		BRKLE 1.125				—			
60000						.990			
62200	.198					—			
63000	.250					1.125 BRKLE			
64002	.357								
65002	.485								
67002	.755								
68002	.919								
68502	1.125 BRKLE								
105000							.174		
106600							.300		
108600							.470		
110600							.694		
112000							.917		
112500							1.125 BRKLE		
149000					CRACKED			CRACKED	
154000				.145					
157000				.211					
161000			.134	.332					
162000			.329	.378					
163100			.68	.515					
164000			.92	.635					
164500			1.20	.745					
165000			1.72	1.125 BRKLE					
165410			TO EDGE TO FASTN. A3						
165470									
165700	↓	↓	↓	↓	↓	↓	↓	↓	.445
165710									1.125 BRKLE
165783	F	A	I	L	U	R	E	—	—



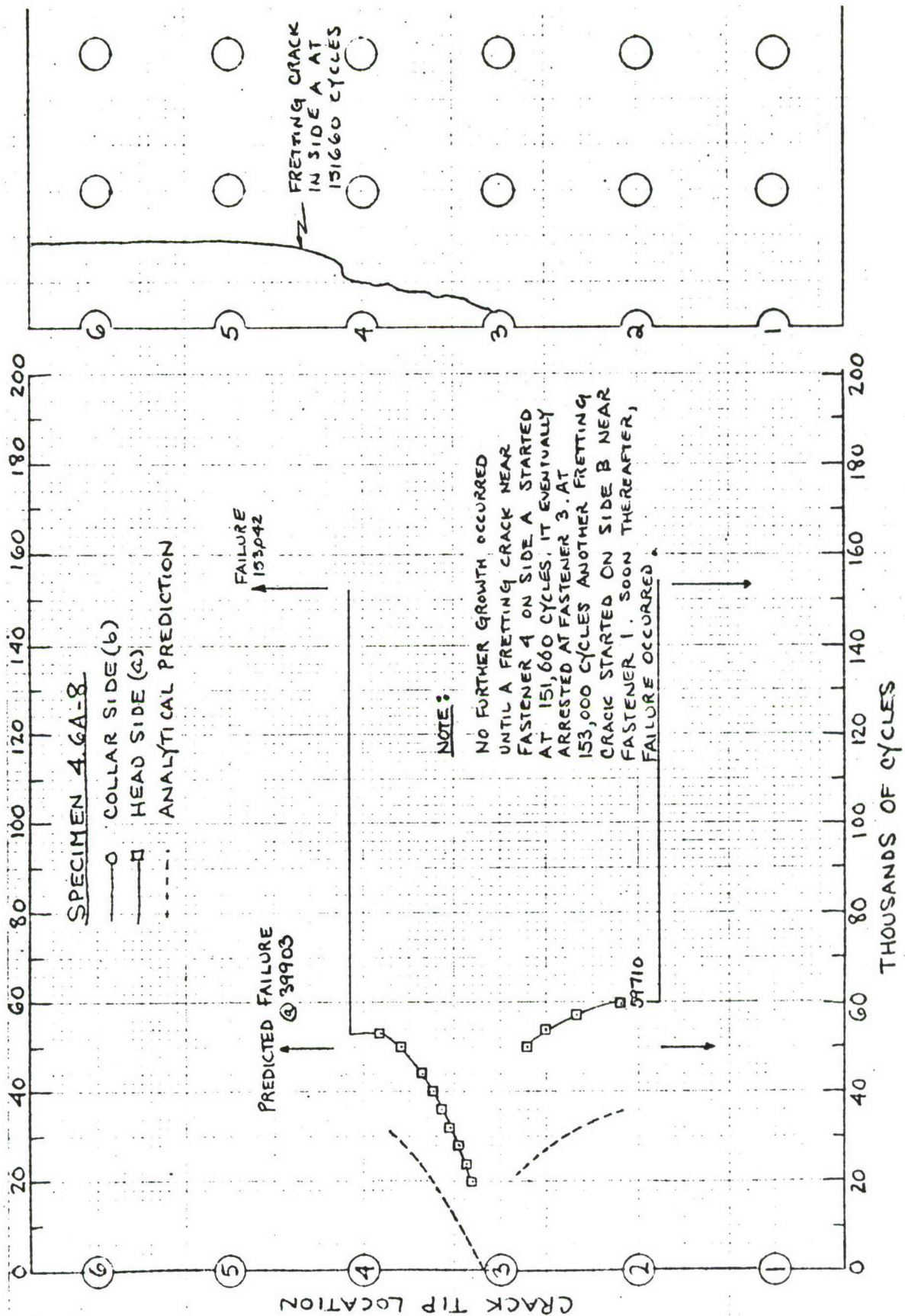
SPECIMEN 4.6A-6

[illegible]



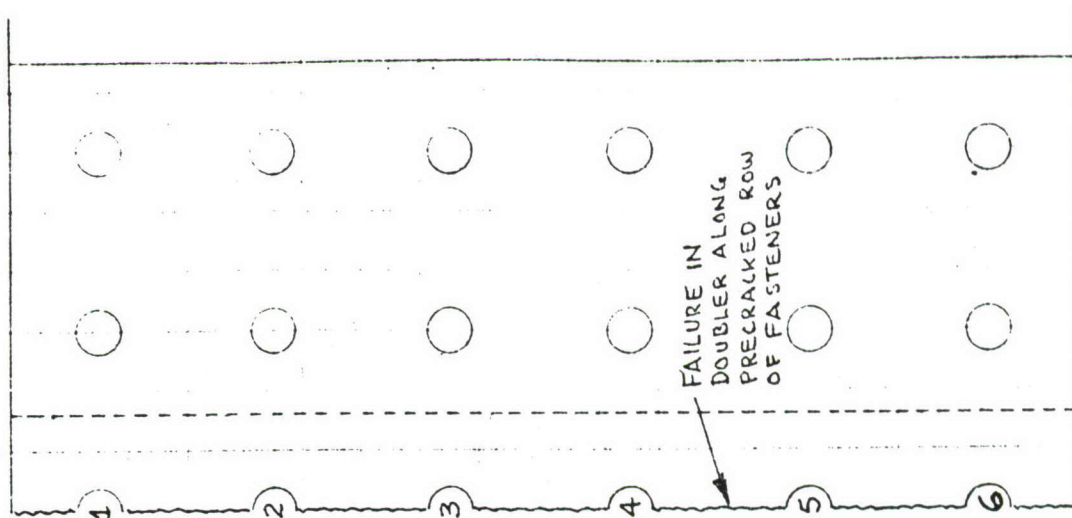
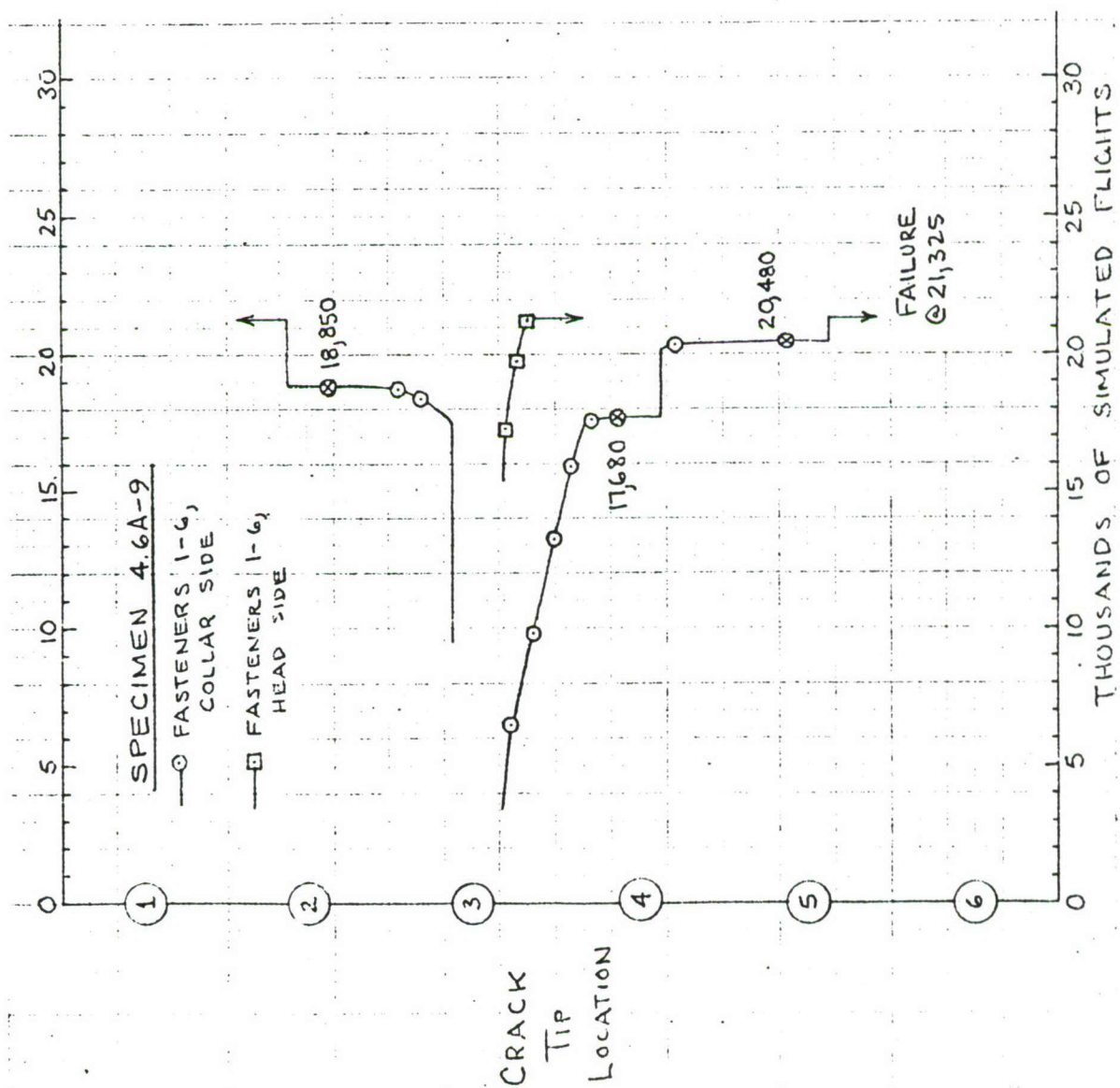
SPECIMEN 4.6A-7

N	a _{F3}	a ₄₃	a ₄₅	b ₄₅	b ₄₃	
22500		.131				
25000		.169				
30000		.248				
35000		.336				
40000		.434				
45000		.540				
50000		.655				
55000		.795				
60000		.958				
62000		1.042				
68495		BROKEN THRU	.320			
70000			.435			
71000			.515			
73000			.671			
75000			.957			
75320			1.125 BROKE			
122202				.276	.441	
125002				.485	.593	
127504				.645	.752	
129504				.835	.928	
130000				.888	.988	
131000				1.125 BROKE	1.125 BROKE	
162500	.15					
165000	.36					
167000	.60					
168000	.74					
169000	.92					
170000	1.24					
170700	1.66					
171200	2.14					
171700	2.78					
171850	3.62					
171900	5.00 TO EDGE					
173139	FAILURE					



SPECIMEN 4.6A-8

[illegible]



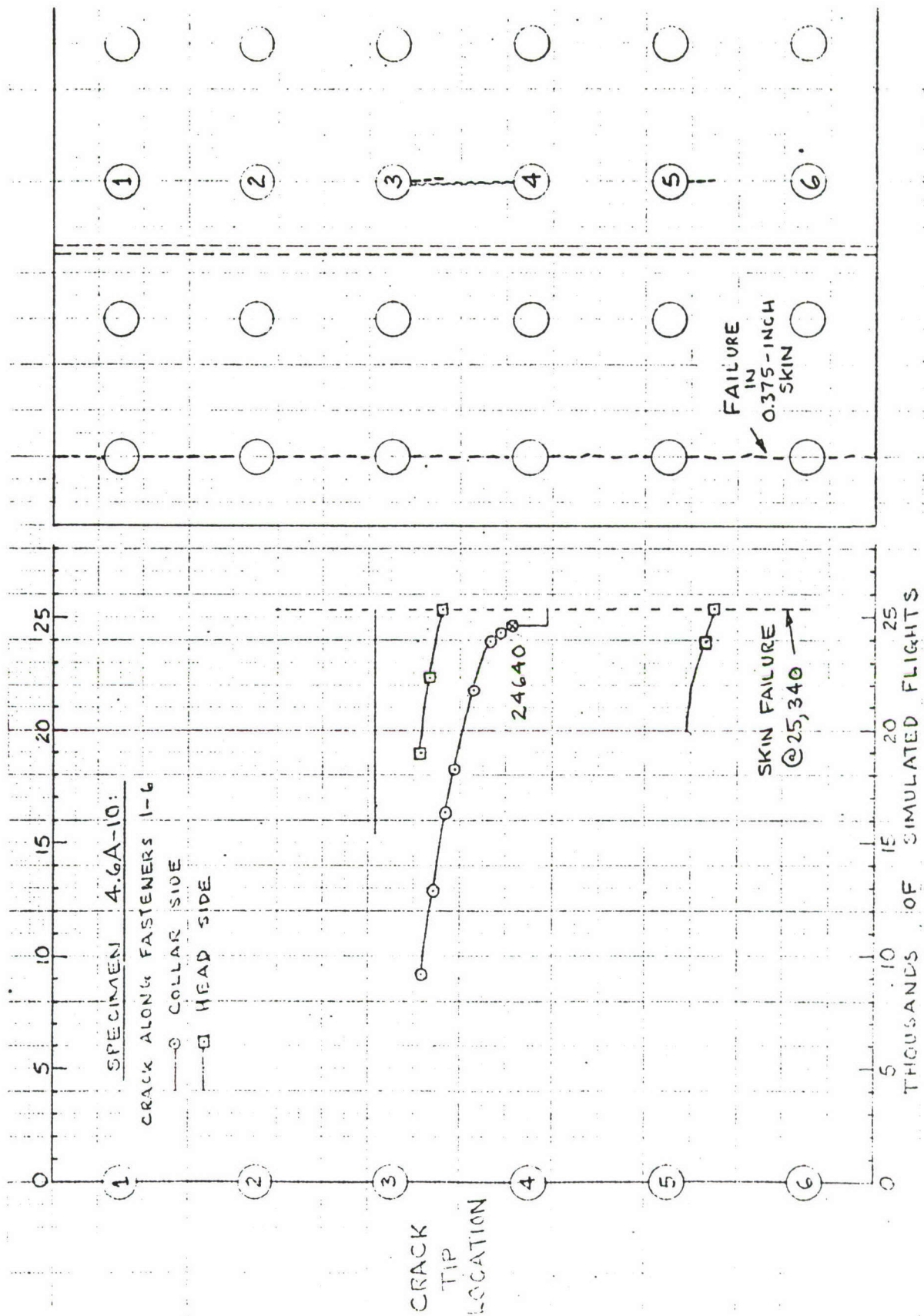
SPECIMEN 4.6A-9

DATA SHEET(S) : 573605-08

TEST DATE(S) = 10-1-76 To
10-6-76

FLTS	a ₃₄	b ₃₄	b ₃₂	b ₄₅	b ₅₆				
6480		0.158							
6800		0.177							
7200		0.215							
7920		0.253							
8720		0.294							
9840		0.359							
11680		0.441							
12640		0.498							
13280		0.533							
14400		0.587							
15200		0.646							
15920		0.690							
16160	DIMPLE	0.703							
16720	—	0.748							
17280	0.119	0.803							
17600	0.130	0.881							
17680	—	CRACK TO FASTENER							
18240	0.149								
18400	0.161		0.281						
18750	0.167		0.477						
18850	0.179		CRACK TO FASTENER						
18960	0.202								
19760	0.218								
20320	0.264			0.135					
20480	0.278			CRACK TO FASTENER					
21280	0.310								
21325		FAILURE			(.030)*				

*Seen on fracture surface;
present just before failure.

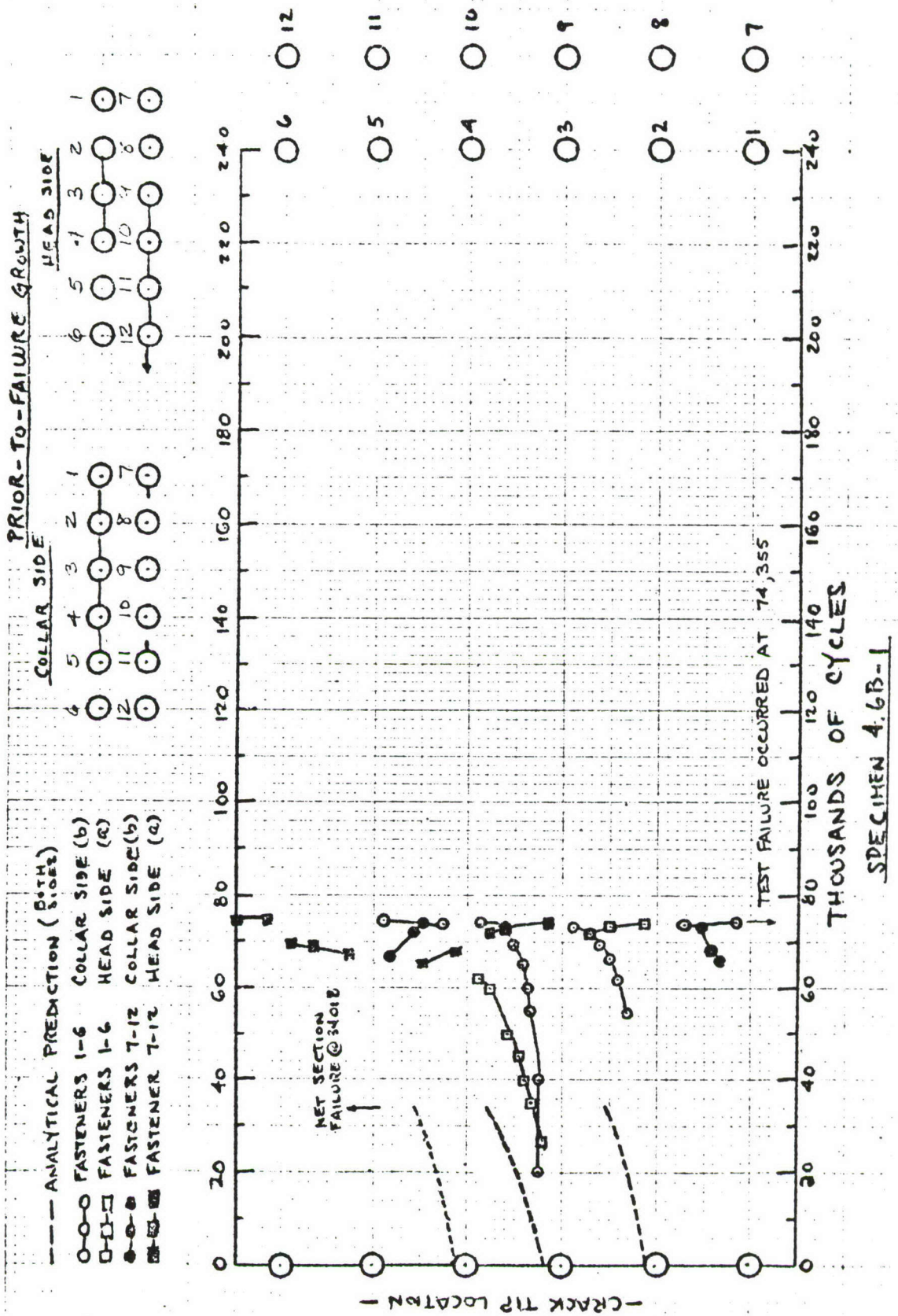


SPECIMEN 4.6A-10

DATA SHEETS : 573609-11

TEST DATES : 10-7-76 TC
10-18-76

FLTS	^a 56	^a 34	^b 34	^b 21
7960			DIMPLE	
9200			0.139	
9440			0.170	
10960			0.221	
11760			0.236	
12880			0.272	
13680			0.296	
14000			0.320	
14800			0.344	
15520			0.374	
16320			0.409	
16720		DIMPLE	0.423	
17040			0.453	
18240			0.502	
18960		0.130	0.531	
19760		0.154	0.581	
20640		0.171	0.633	
21280		0.197	0.666	
21760		0.212	0.713	
22400		0.225	0.738	
23440		0.273	0.826	
23920	0.215	0.294	0.879	
24320	0.231	0.308	0.997	
24640	0.231	0.326	CRACK TO FASTENER	
25040	0.290	0.353		
25340	0.311	0.367	DIMPLE	
25340	FAILURE IN MAIN SHEET ACROSS THE OUTSIDE FASTENER ROW. NO VISIBLE CRACKS APPEARED ON THE DOUBLER PRIOR TO FAILURE			

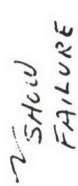


MD = R1.075
COLLAR = R4.080

4,6B-1

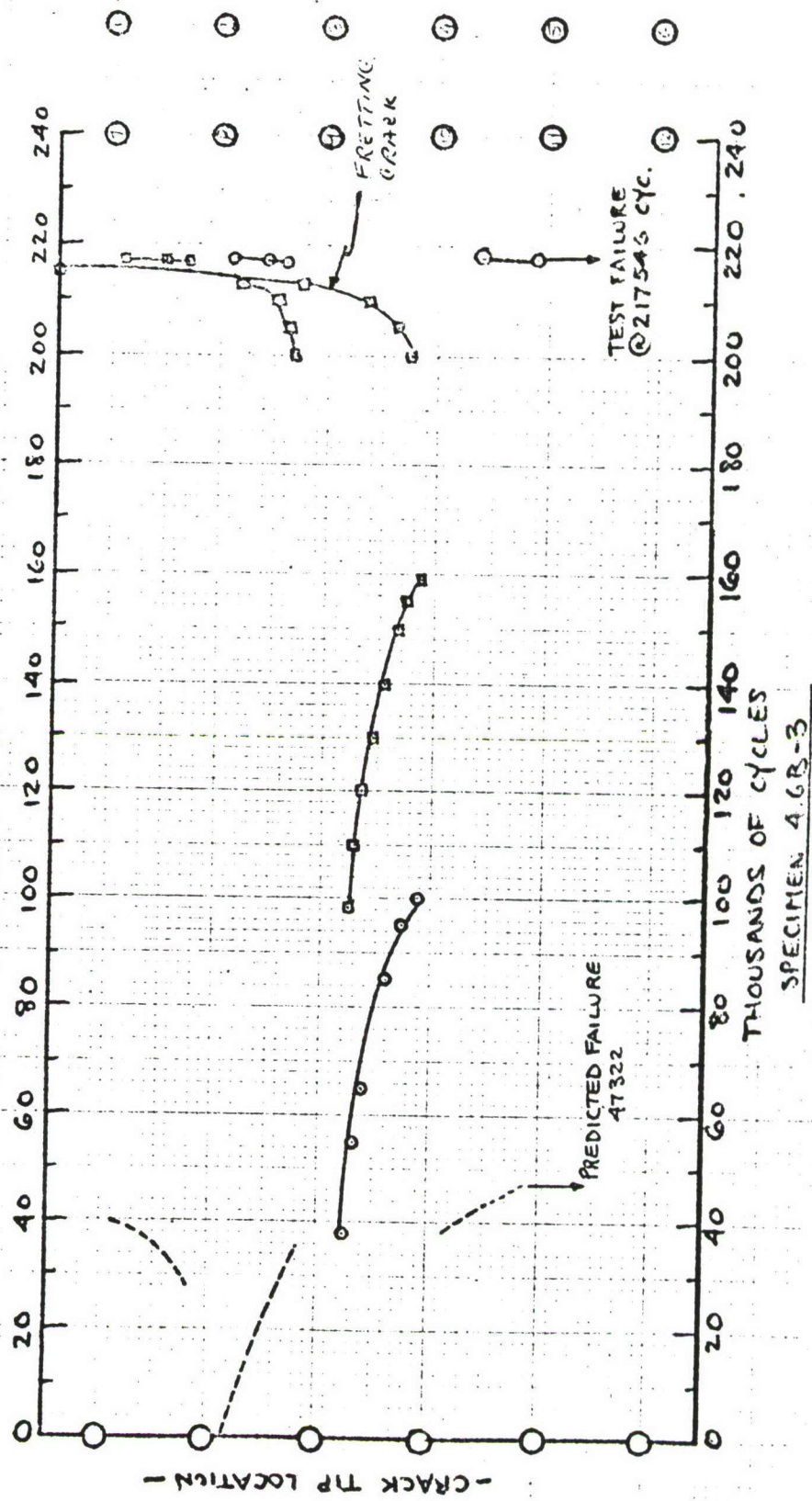
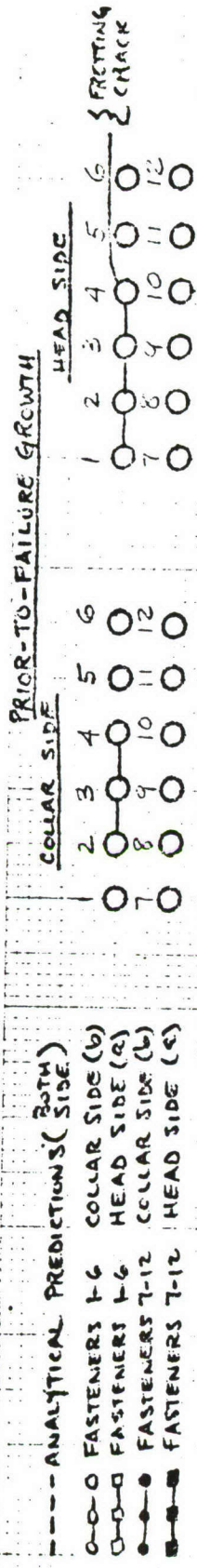
SPECIMEN

N	a7E	a97	a99	a98	a96	a34	a45	b12-11	b56	b54	b43	b32	b89
20000											.102		
25000						.097					.118		
30000						.150					↑		
35000						.204							
40000						.263					.118		
45000						.325					.135		
50000						.458					.166		
55000						.505				.186	.201		
60000						.635				.256	.242		
61750						.750 BRIDGE				.288	.250		
65000			.405					.182		.345	.282		
65900			.415	.181				.196		.365	.292		
66590			.750 BRIDGE					.196		.378	.302		
67000		.165								.382	.317		.160
68200		.355						.280		.432	.362		.180
69000		.525						.280		.460	.364		.230
69450		.750 BRIDGE						.290		.482	.370		.230
71800							.155	.330		.550	.410		.280
72100					.095		.175	.340		.560	.420		.290
72400					.275		.245	.360		.58	.44		.320
73000					.395		.315	.360		.62	.44		.320
73500					.495		.375	.380		.730 BRIDGE	.48		.35
73790					.655		.750 BRIDGE	.40			.54		.35
74000					.750 BRIDGE			.41			.63		.38
74097	.750 BRIDGE							.41			.750 BRIDGE	.160	.40
74245								.41	.33		.750 BRIDGE	.750 BRIDGE	.40
74281								.41	.750 BRIDGE				.40
74355			P	A	I	L	U	R	E				



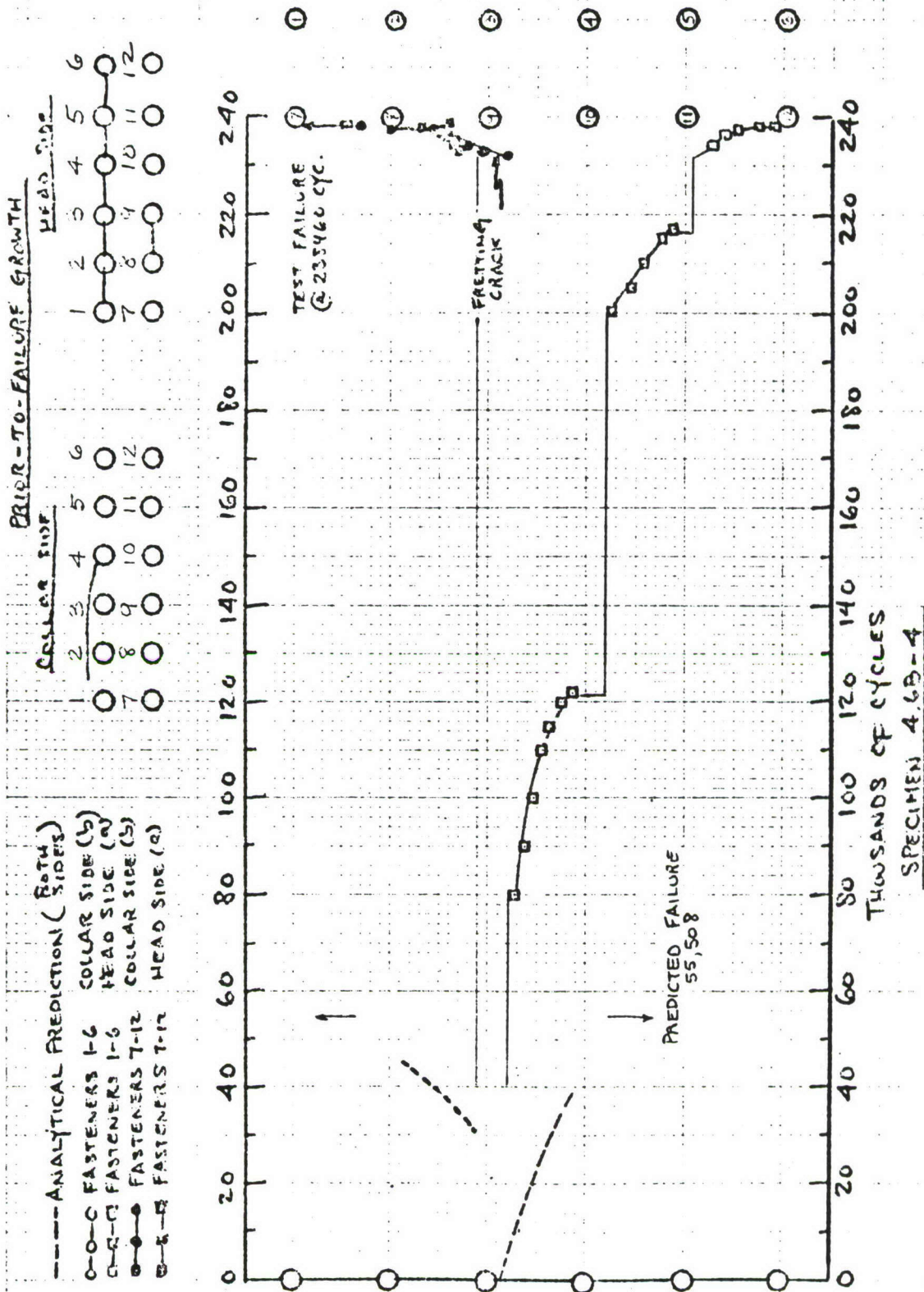
SPECIMEN 4.6B-2

N	a ₃₄	a ₁₀₋₉	a ₁₁₋₁₀	a ₁₂₋₁₁	a _{12E}	b _{12E}	b ₁₂₋₁₁	b ₁₁₋₁₀	b ₁₀₋₉	b ₃₄
35000										.122
40000										.155
45000										.198
50000				.103						.245
55000				.315						.300
58000				.395						.356
60000			.175	.455						.365
62000			.215	.555						.404
62580			.255	.75 BRUCE						
65000	.115		.375		.375 BRUCE					.490
65800	.125		.655							.580
66200	.127		.75 BRUCE				.120			.580
70000	.170						.400			.580
70500	.185					.375 BRUCE	.720			.750 BRUCE
70930	.185						.750 BRUCE			
70980	.185							.750 BRUCE		
71227	.189	BRUCE IN 10 CYCLES								
71310		V	V	V	V	V	V	V	.750 BRUCE	V
71320		F	A	I	L	U	R	E		



SPECIMEN 4.6B-3

N	a ₂₁	a ₃₂	a ₃₄	"a ₄₄ "	b ₄₅	b ₃₄	b ₃₂
37600						.101	
45000						.140	
55000						.197	
65000						.266	
75000						.359	
85000						.473	
95000						.605	
98220			.105			.649	
100000			.112			.75 BRUCE	
110000			.169				
120000			.235				
130000			.320				
140000			.425				
150000			.539				
155000			.602				
158690			.75 BRUCE				
200000		.172		.107			
205000		.240		.256			
210000		.342		.446			
212600		.75 BRUCE		1.10			
214930				TO EDGE			
216300	.175						
216480	.375						
216620	.750 BRUCE						.28
216970							.43
217270							.53
217540					.33		.75 BRUCE
217546	F	A	I	L	U	R	E



SPECIMEN 4.6B-4

N	a ₈₉	a ₁₂	a ₃₂	a ₃₄	a ₄₅	a ₅₆	b _{FH}
80000				.165			
(MARK CYS)				.187			
90000				.257			
100000				.345			
110000				.440			
115000				.491			
120000				.607			
121600				.750 BROKE			
200000					.162		
205000					.333		
210000					.456		
213000					.557		
215000					.617		
217000					.731		
217110					BROKE THRU		
232000							.68
233150			.180				.90
233250			.190				1.10
234150			.220			.145	1.12
235650			.255			.255	1.22
236150			.275			.275	1.34
236550			.375			.355	1.50
237000			.395			.375	1.60
237400						.435	1.72
237500	.295		.395			.435	1.76
237800	.325		.495			.555	1.90
238000	.395		.575			.775	1.90
238090	.415	.355	.655			BROKE	1.90
238250	.425	.355	.675				2.25
238460	F	A	I	L	U	R	E

SECTION IV

SINGLE LAP JOINTS

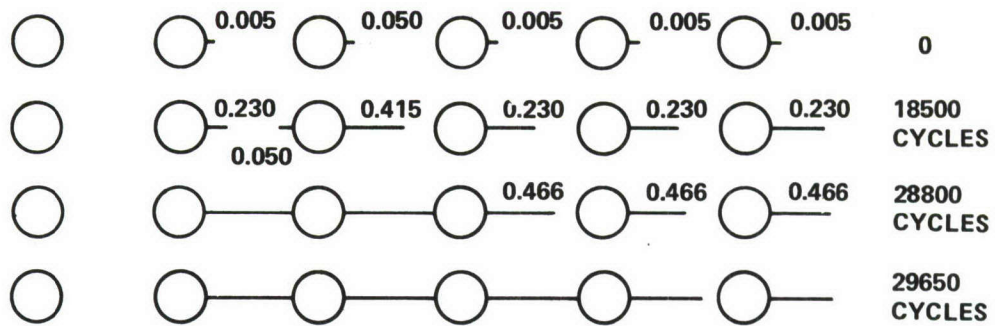
Crack growth predictions and test data are summarized in this section for the single lap joint specimens. Predictions are available only for Specimens 4.7-1 through -8, which were constant amplitude tested. Specimens 4.7-10 through -13 were 80-flight spectrum tested. Simplified crack growth life predictions were made for these specimens based upon the corresponding constant-amplitude results, but no detailed prediction of cracking sequence was done. There are three constant-amplitude predictions corresponding to three combinations of fastener clearance and continuing damage condition. Figure 2 shows the predicted damage sequences as well as the estimated crack lengths versus applied load cycles for these three predictions.

Crack growth data are presented in the following tables in terms of crack length versus number of cycles along with a graphic presentation of the crack path for the twelve single lap joint specimens tested. They are presented face-to-face to facilitate cross reference. Specimen configurations and initial damage conditions for each specimen are identified in Figures 4 and 6 and Tables 2 and 4 of Volume I.

Of the twelve specimens, Specimens 4.7-1 through 4.7-8 were constant amplitude spectrum tested, and Specimens 4.7-10 through 4.7-13 were 80-flight spectrum tested. The applied cyclic stress for the constant amplitude tests was $S_{\max} = 17$ ksi, $R = 0.1$. There are two reference maximum stress levels for the 80-flight spectrum tests; $S_{\text{ref}} = 25$ ksi for Specimen 4.7-10 and $S_{\text{ref}} = 30$ ksi for Specimens 4.7-11 through 4.7-13. The load sequence of the 80-flight spectrum is shown in Figure 7a of Volume I.

The notations used in the following data tables are similar to those used on double lap joint specimens in Section III. The fasteners are numbered 1 through 7 in the precracked row, with the precrack at Fastener 4. Side "A" is the fastener-head side of the specimen (hence, the skin member) and Side "B" is the collar side (hence, the doubler). Thus a_{43} is the length of the main crack in the skin, originating at Fastener Hole 4 and growing toward Fastener Hole 3.

CLEARANCE FIT, CONTINUING DAMAGE, SPECIMENS 4.7-2 AND 4.7-3



CLEARANCE FIT, NO CONTINUING DAMAGE, SPECIMENS 4.7-1 AND 4.7-4



INTERFERENCE FIT, NO CONTINUING DAMAGE, SPECIMENS 4.7-5 TO -8

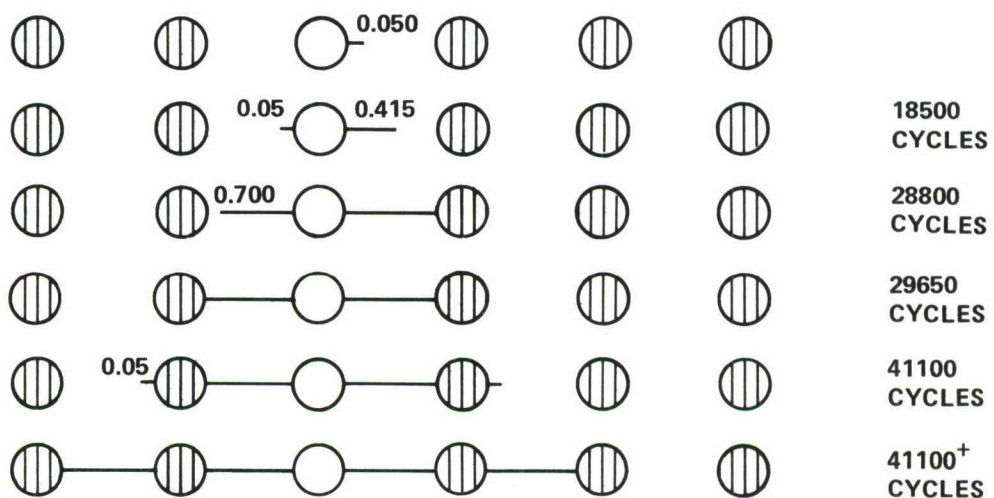
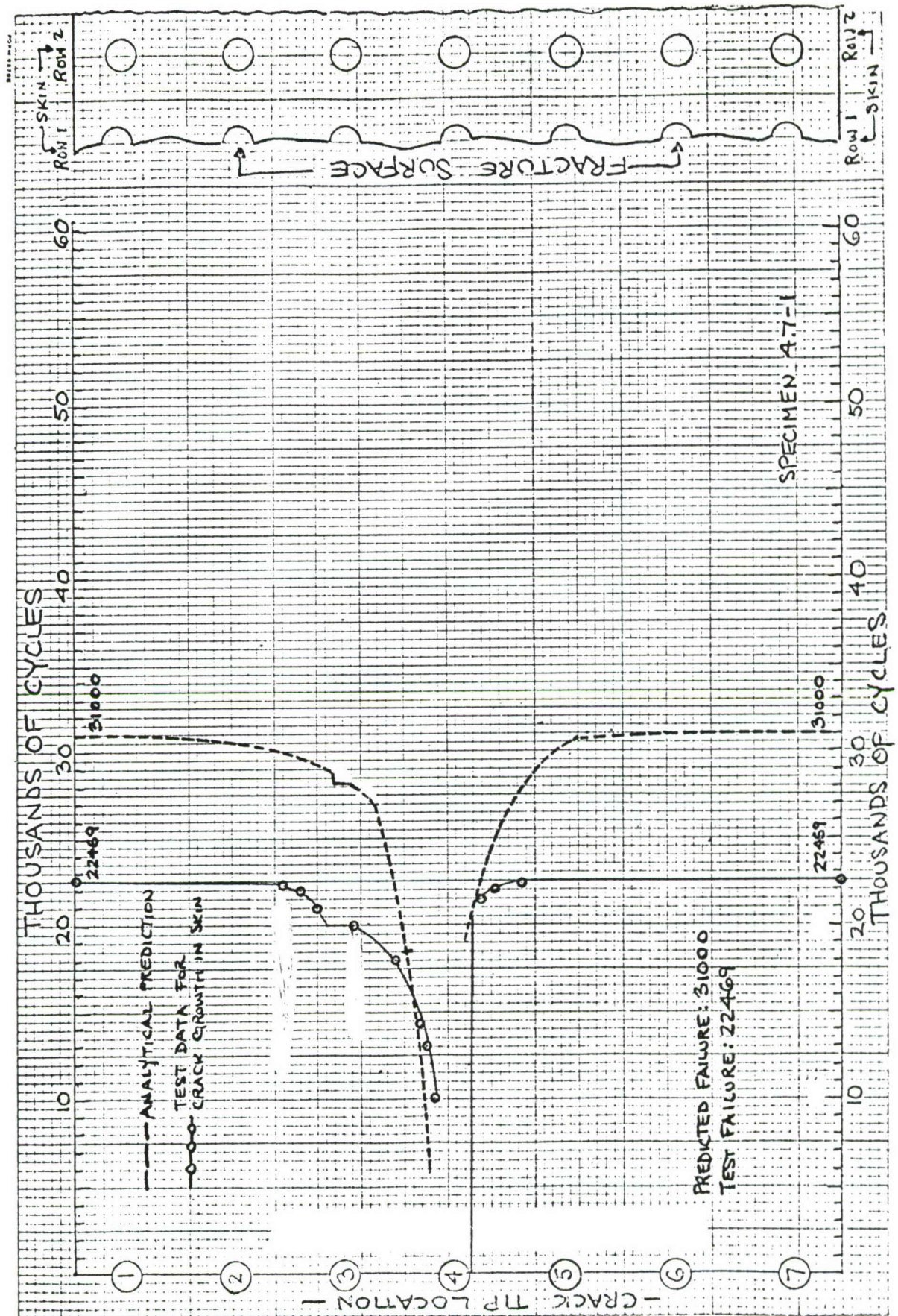


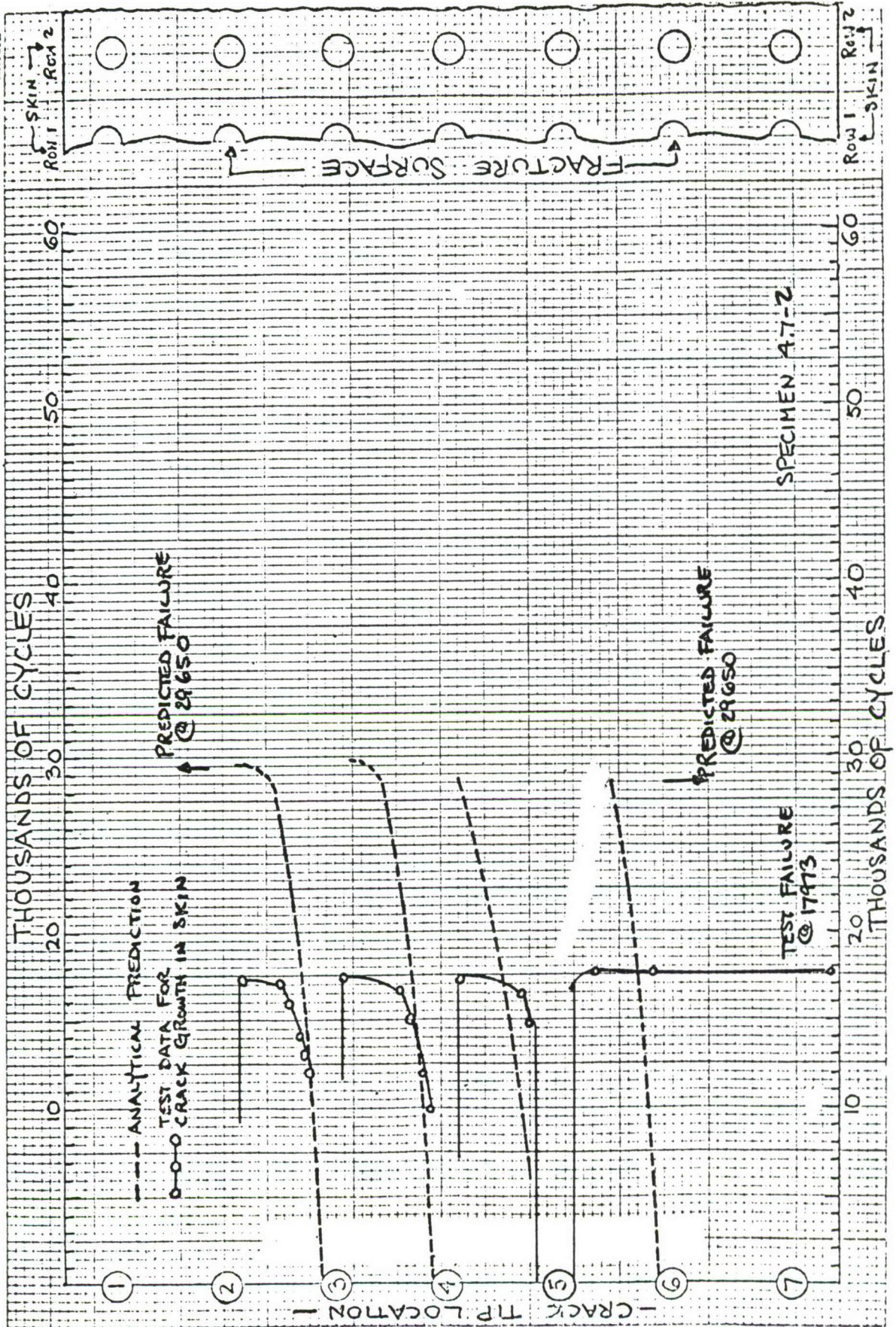
Figure 2. Predicted Crack Growth Sequence, Single Lap Joint Specimens

In some cases cracking occurred at the outermost fastener hole and grew toward the free edge. In this instance, the notation "E" is used to denote the edge of the specimen. Thus a_{7E} is the length of a crack in the skin originating at Fastener Hole 7 and growing toward the edge of the specimen.



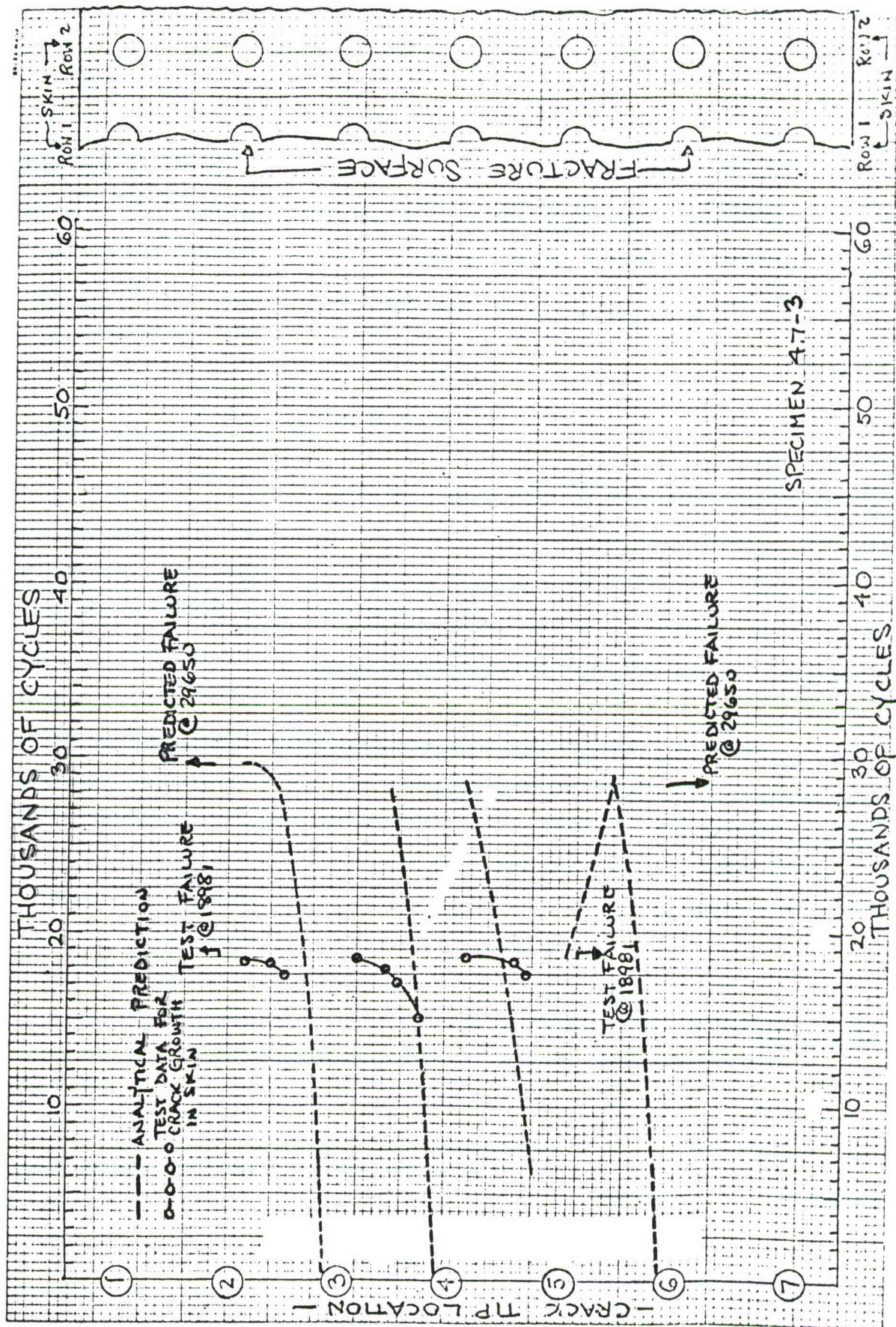
SPECIMEN 4.7-1

N	a ₃₂	a ₄₃	a ₄₅	
10,000		.109		
11,000		.140		
12,000		.168		
14,000		.250		
16,000		.373		
18,000		.526		
20,000		458 BROKE		
21,000			.114	
22,000	.168		.318	
22,400	.399		.511	
22,469	F A I L U R E			



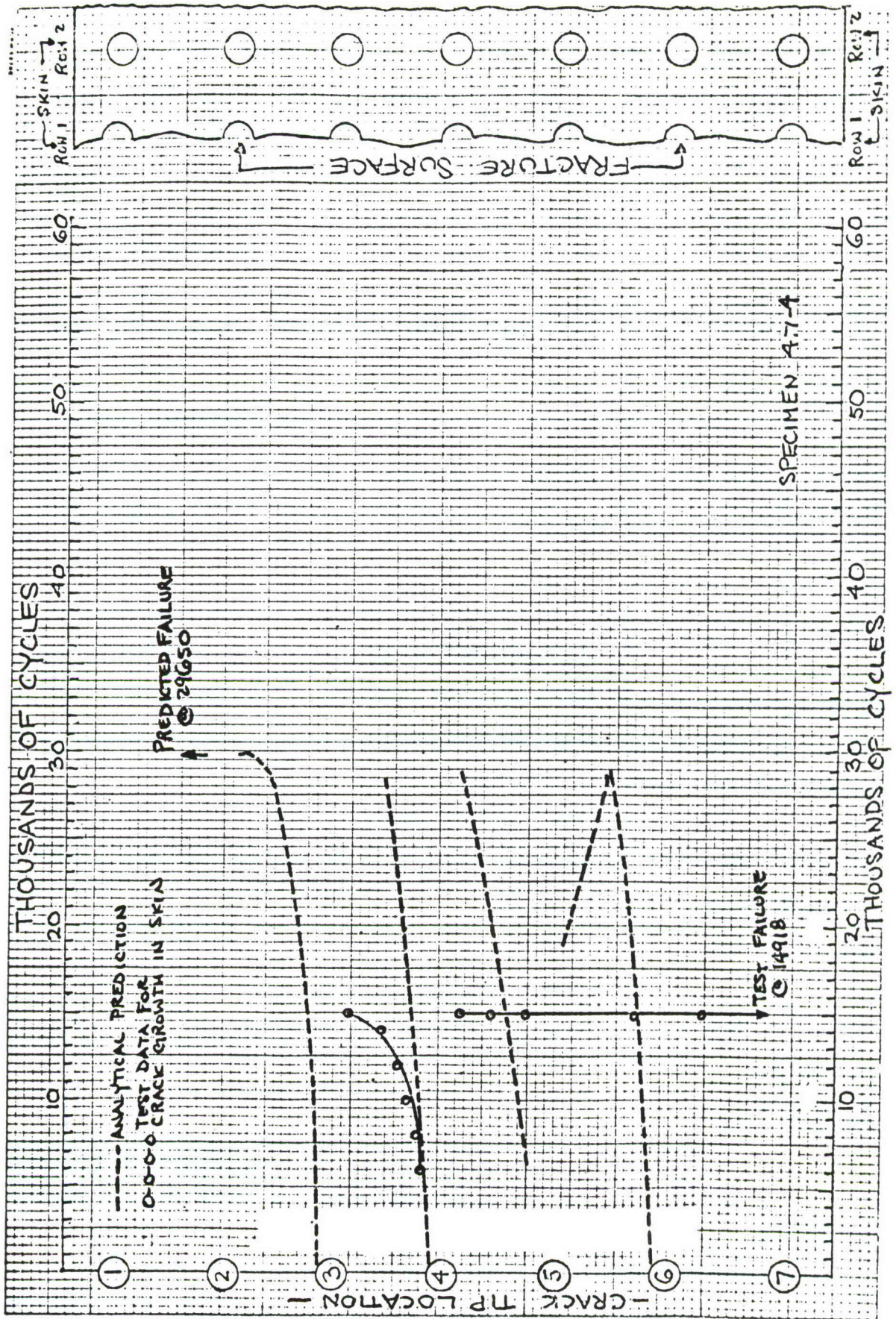
SPECIMEN 4.7-2

N	a ₅₆	a ₅₄	a ₄₃	a ₃₂
10,000			"DIMPLE"	
12,000			.100	.100
13,000			.145	.150
14,000			.178	.206
14,817		.125	.208	.253
16,002		.167	.273	.331
16,502		.192	.302	.375
17,002		.220	.340	.419
17,472		BROKE	BROKE	BROKE
17,778	.243			
17,789	BROKE			
17,973	FAIL	UR	E	



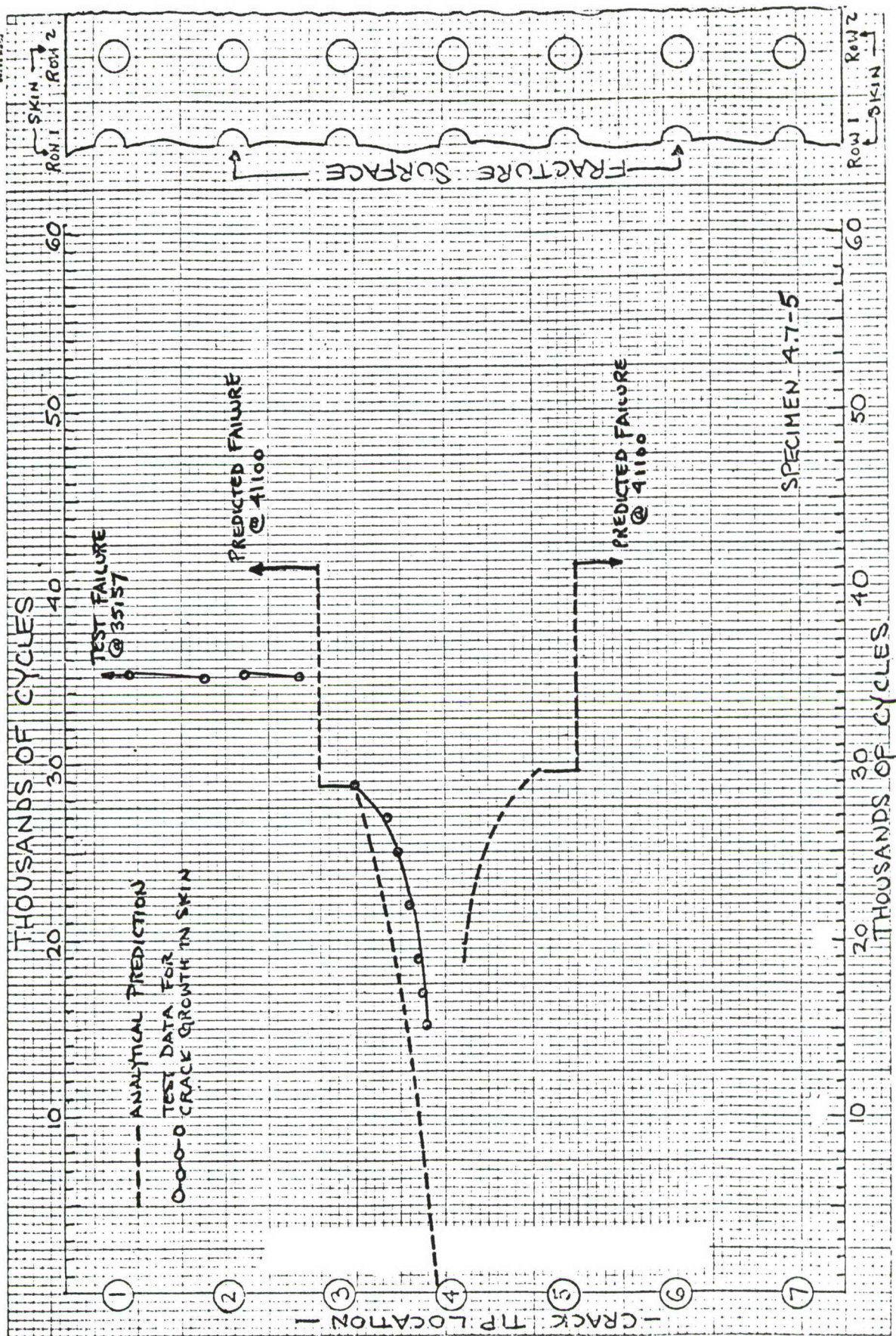
SPECIMEN 4.7-3

N	Q ₃₂	Q ₄₃	Q ₅₄	
	(.005)	(.050)	(.005)	
15,000		.190		
17,000		.430		
17,530	.440	.506	.284	
17,700	.486	.546	.388	
18,300	.600	BROKE	.388	
18,315	BROKE		—	
18,400			.405	
18,507			BROKE	
18,981	F A I L U R E			



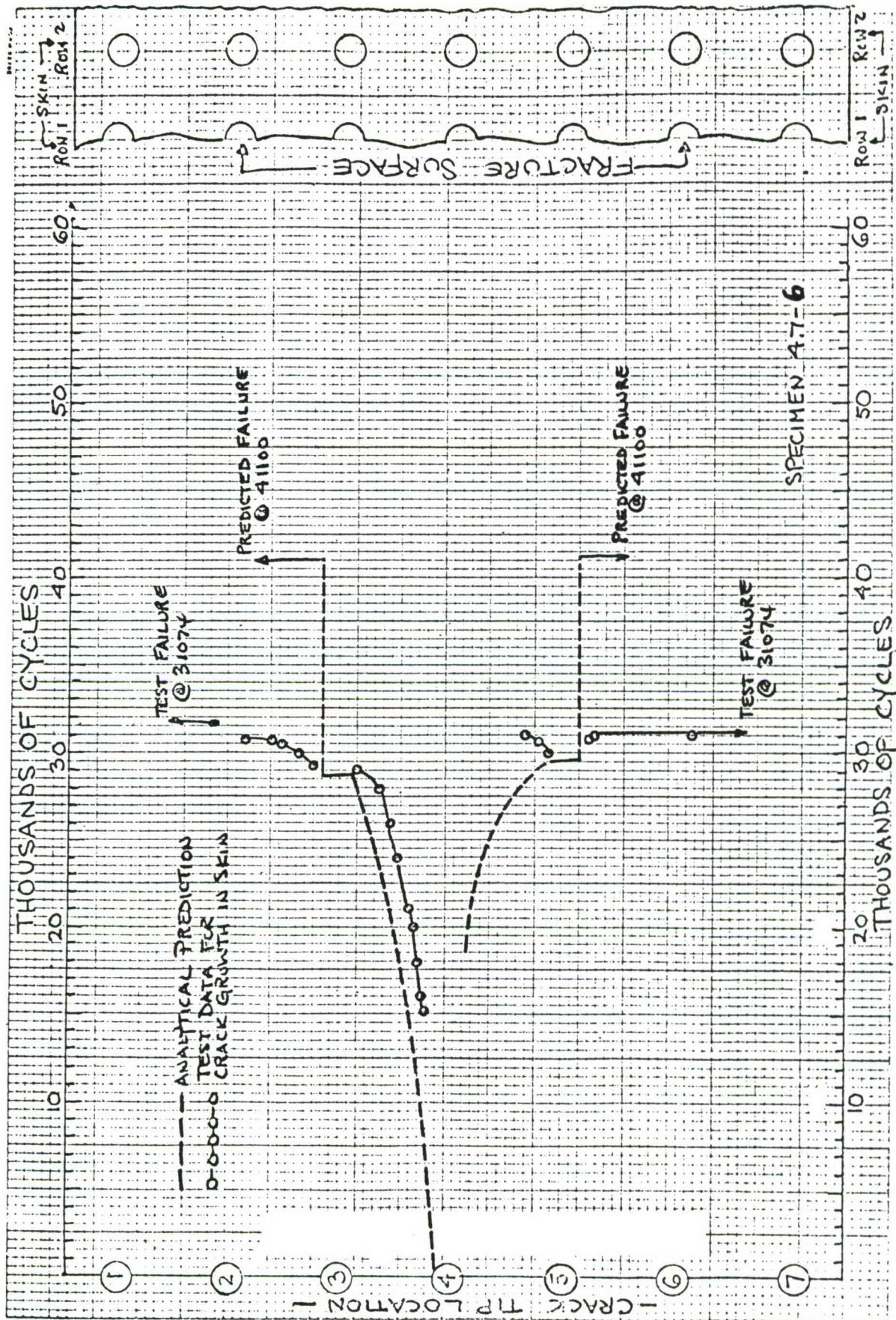
SPECIMEN 4.7-4

N	a43	a45	a54	a65	a67
6000	.100				
8000	.180				
10000	.283				
12000	.381				
14000	.537				
14917	BROKEN THRU	.35	(~.2)	(~.2)	(~.2)
14918	F A I	L U	R E		



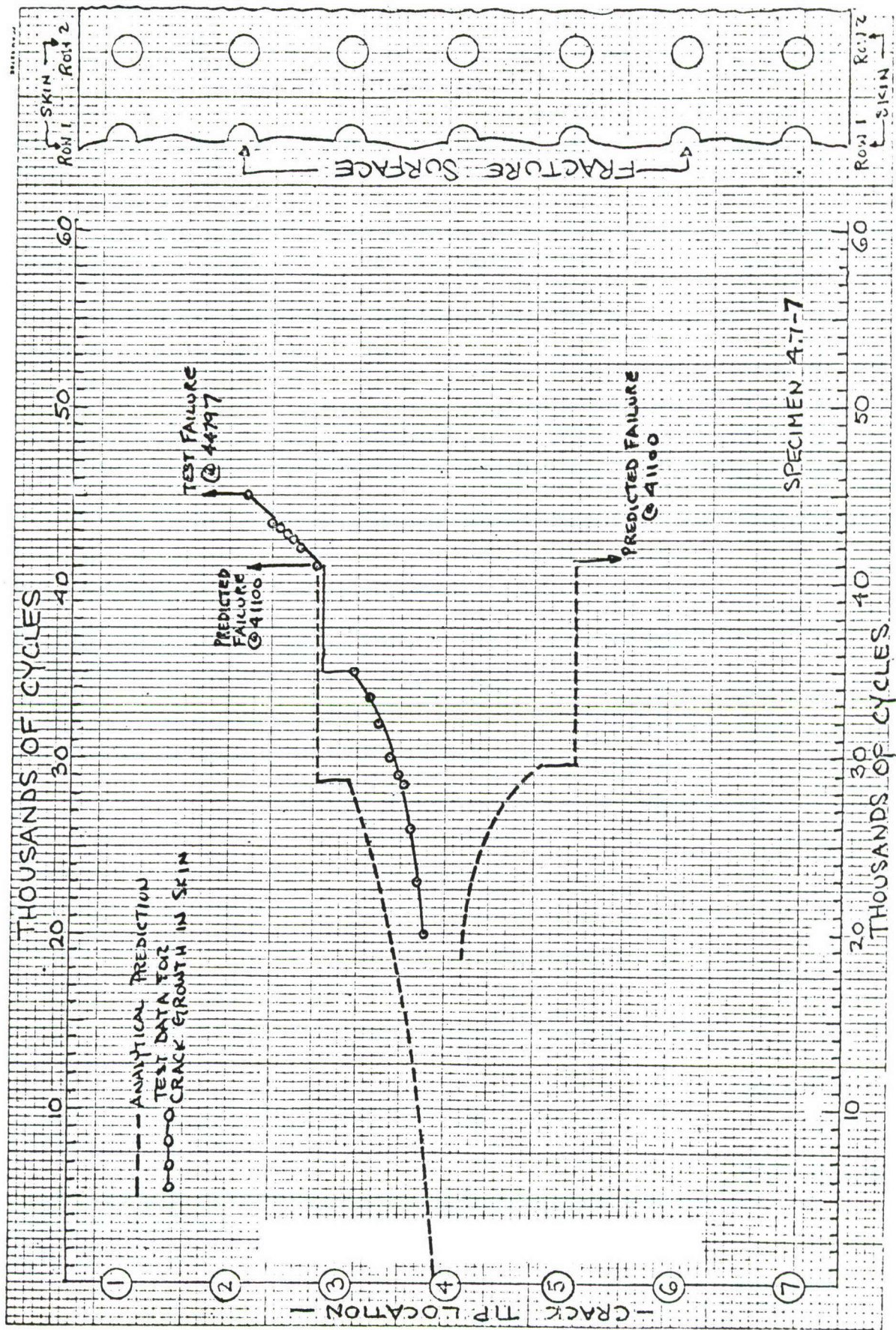
SPECIMEN 4.7-5

N	a ₄₃	a ₃₂	a ₂₁	a _{1E}					
15 100	.100								
16 000	.124								
17 000	.155								
18 000	.180								
19 000	.211								
20 000	.241								
21 000	.277								
22 000	.306								
23 000	.341								
25 000	.429								
27 000	.535								
28 850	.938 BROKE								
35 000		.263	.132						
35 144		.938 BROKE	.938 BROKE	.469 BROKE					
35 157	—	F	A	I					E



SPECIMEN 4.7-6

[illegible]



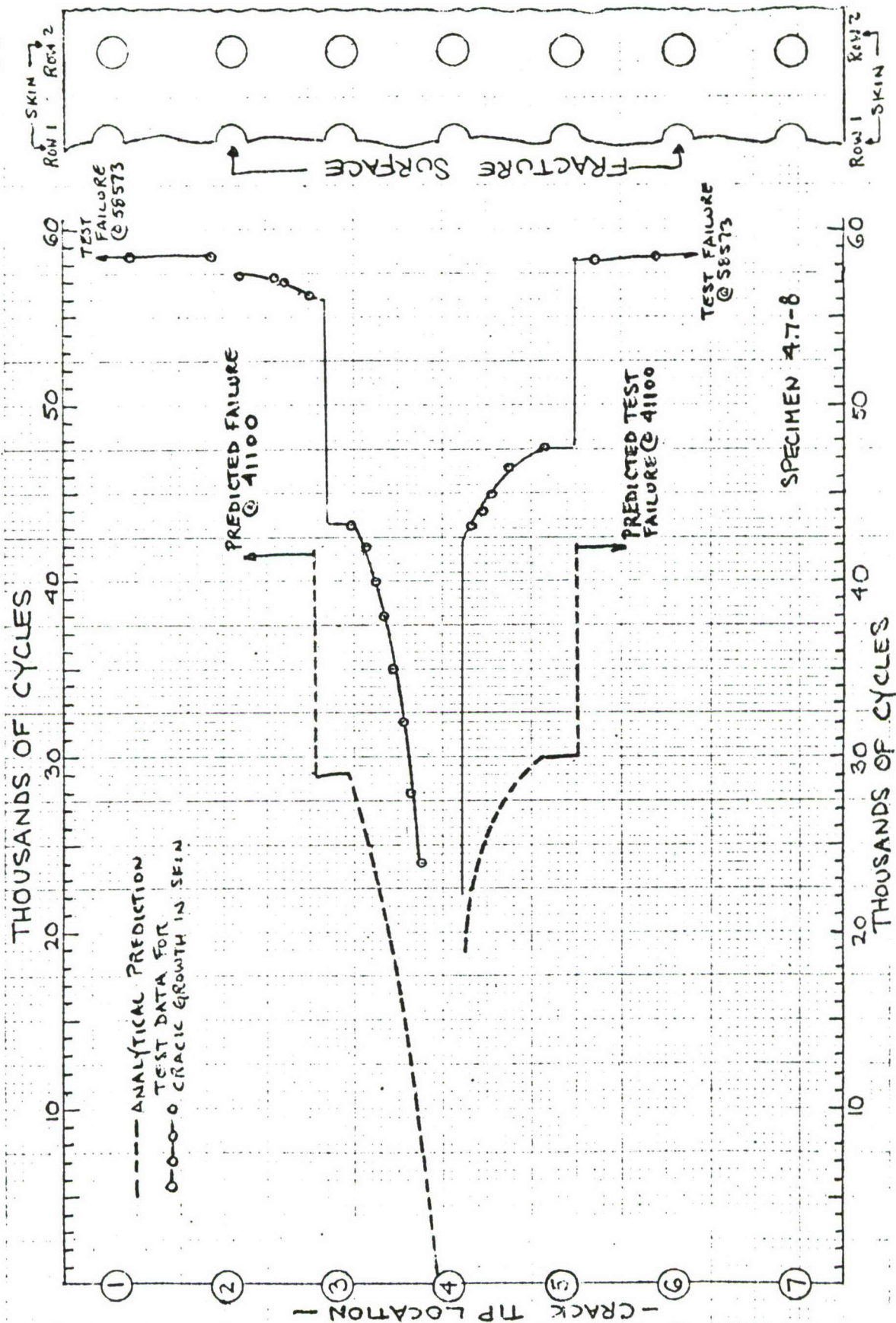
DATA SHEET NO(S) : 357472-74

TEST DATE(S) : 9-21-76 TO
9-22-76

SPECIMEN 4.7-7

N	a_{43}	a_{32}							
20000	0.115								
21000	0.149								
22000	0.172								
23000	0.202								
24000	0.240								
25000	0.266								
26000	0.280								
27000	0.325								
28000	0.364								
29000	0.424								
30000	0.504								
31000	0.561								
32000	0.620								
33000	0.716								
34000	0.766								
35000	BROKE								
36000	THRU								
41000		0.098							
42000		0.257							
42500		0.343							
42800		0.414							
43100		0.497							
43400		0.578							
43700		0.696							
43800		0.726							
43900		0.853							
44797	FAILURE								

* POPPING SOUNDS AT
44360 CYCLES, NO
NEW CRACKS SEEN



SPECIMEN 4.7-8

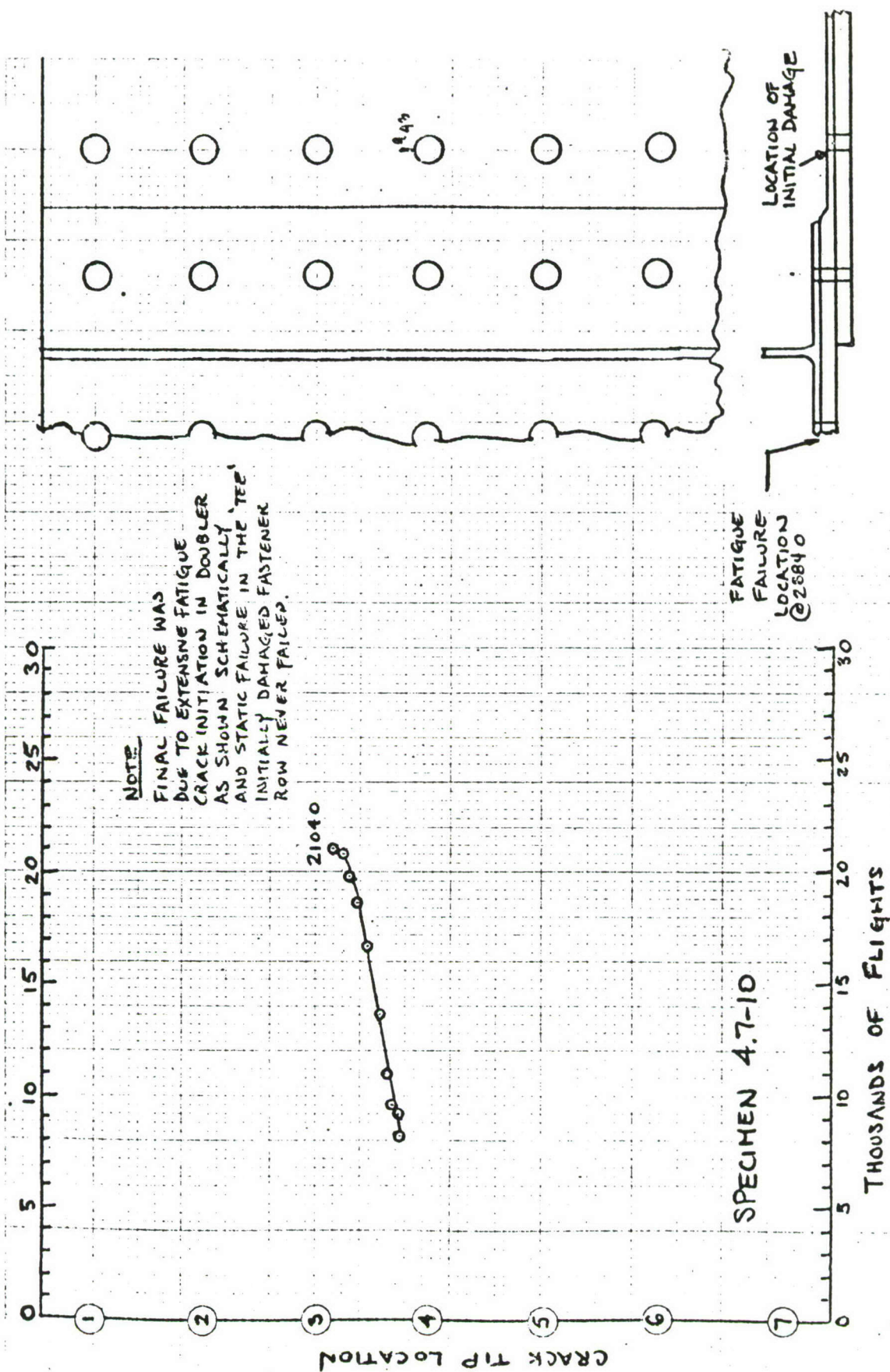
DATA SHEET(S) : 357475-78

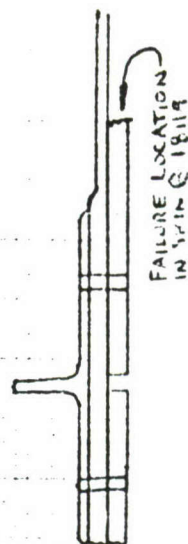
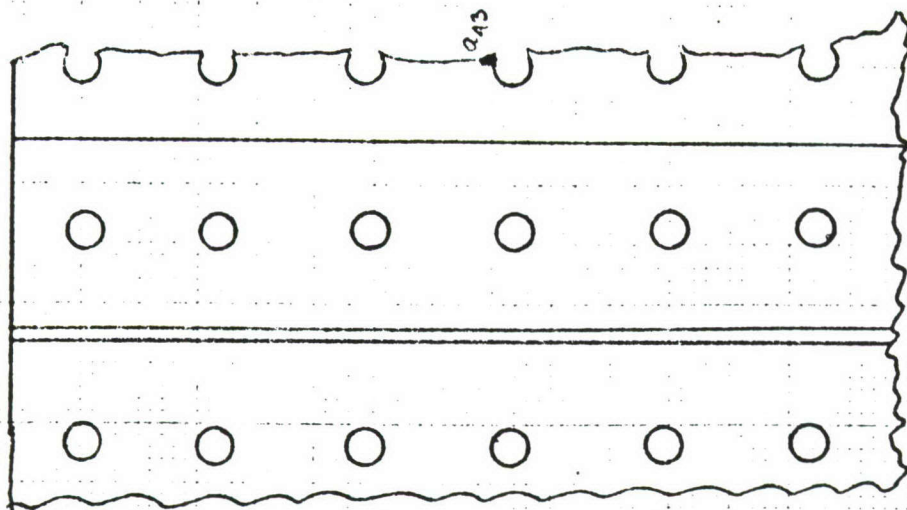
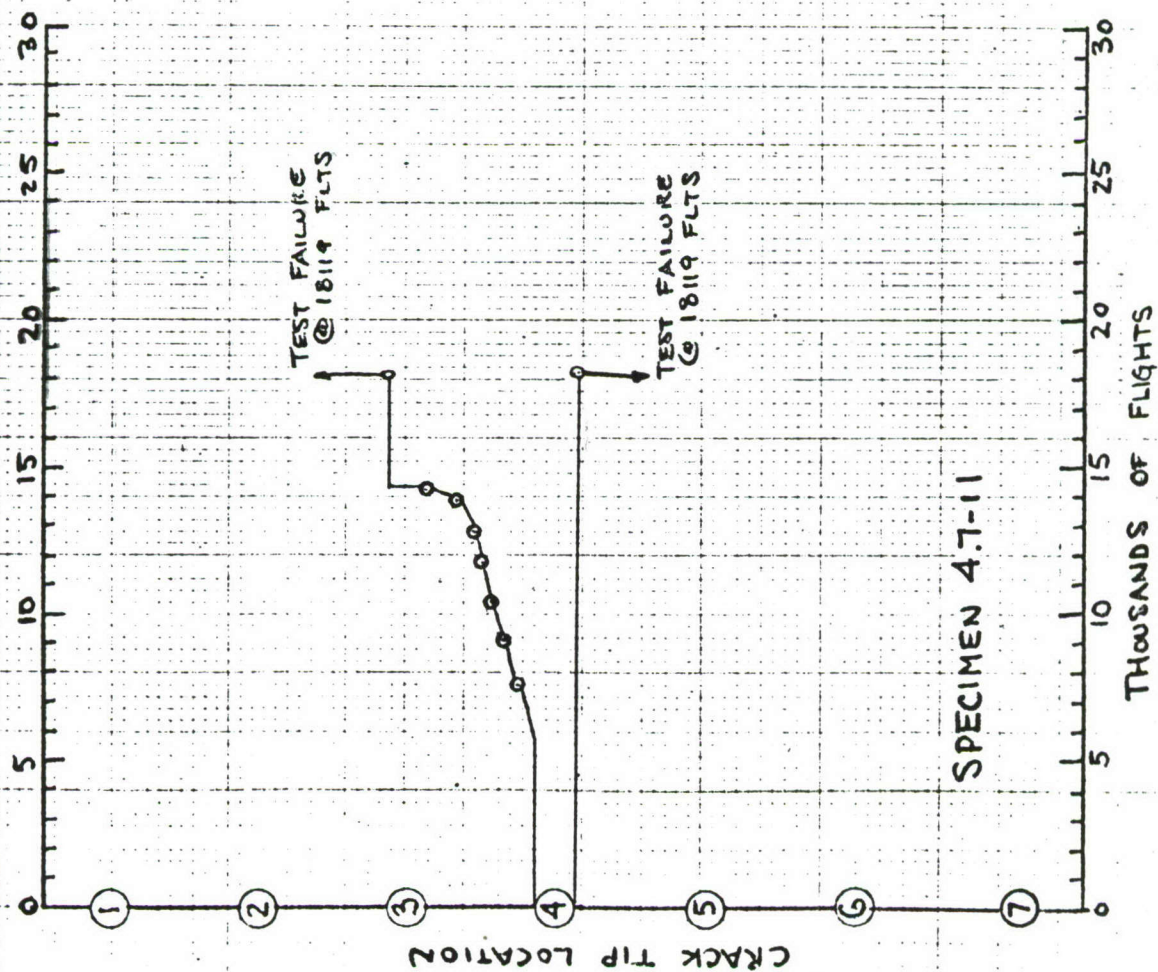
TEST DATE(S) : 9-23-76 T.
9-24-76

N	a ₄₃	a ₄₅	a ₃₂	a ₅₆	a ₂₁ (OR a ₁₂)		
24x10 ³	0.132						
26	0.182						
28	0.233						
32	0.340						
35	0.441						
38	0.558						
40	0.650						
42	0.776						
42.4	0.814						
42.7	0.846						
43.2	CRACK TO FASTENER 0.114						
44.1		0.214					
45.1		0.329					
45.8		0.415					
46.6		0.526					
47.2		0.650					
47.6		0.779					
47.7		CRACK TO FASTENER					
56.3			0.130				
56.4			0.183				
56.8			0.285				
57.05			0.398				
57.25			0.498				
57.35			0.572				
57.45			CRACK TO FASTENER (1)				
58.4				0.210			
58.45				0.470			
58.475				CRACK TO FASTENER (2)			
58.509					CRACK TO FASTENER		
58.573		FAILURE					

NOTES : (1) CRACK ORIGINATED AWAY FROM NET SECTION
BETWEEN HOLE 5 AND HOLE 6

(2) CRACK WAS FIRST OBSERVED FROM FASTENER
TO FASTENER



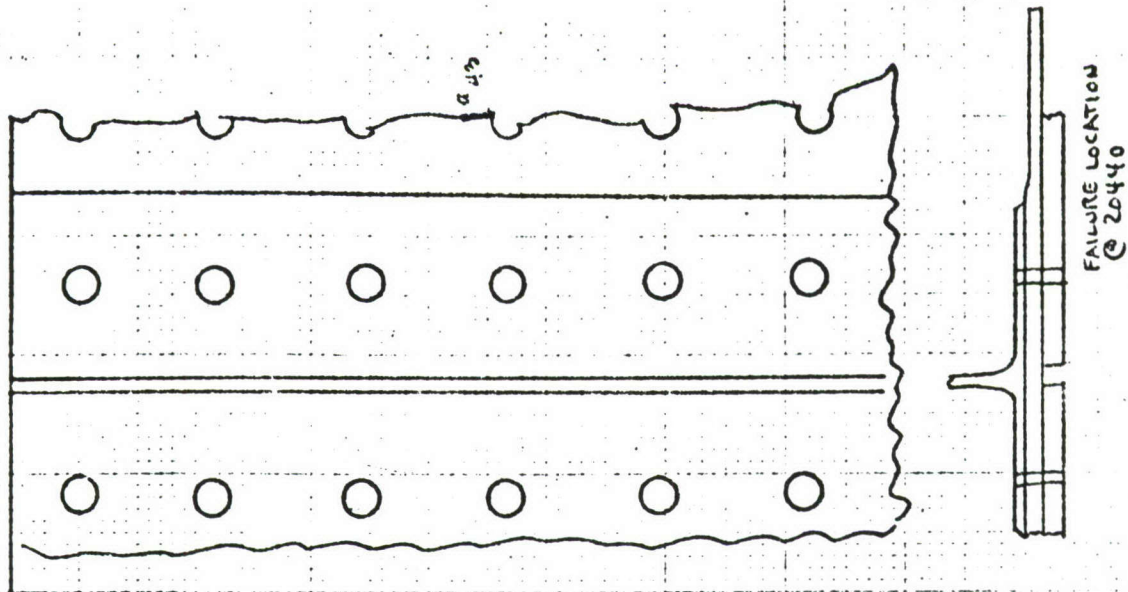
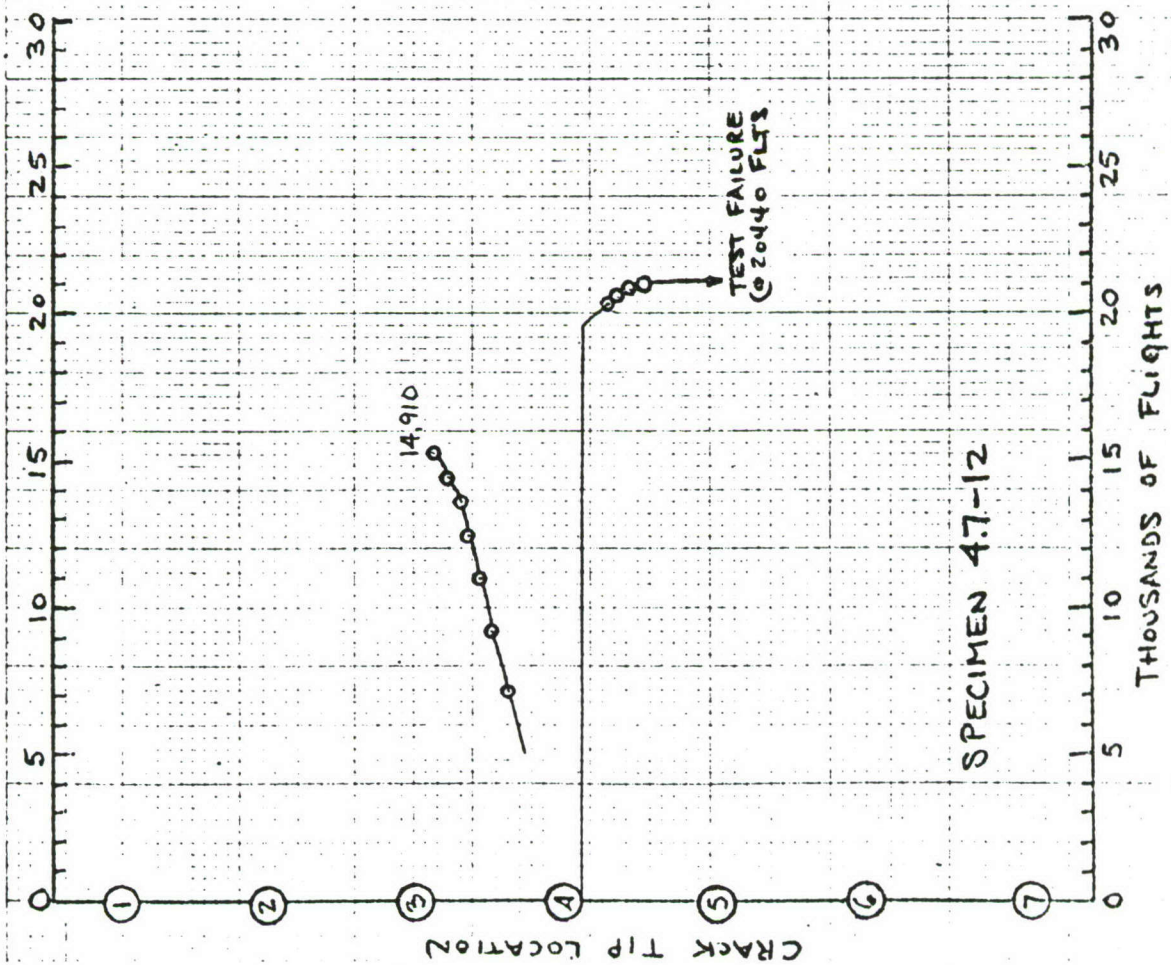


DATA SHEET(S) : 573323-24

TEST DATE(S) : 4-6-77

SPECIMEN 4.7-11

FLTS	α_{43}	
1520	—	
6080	—	
7600	0.132	* DIMPLE ON SURFACE
9120	0.265	
9440	0.297	
10240	0.348	
10640	0.365	
11120	0.385	
11760	0.420	
12160	0.455	
12560	0.485	
12800	0.508	
13040	0.524	
13360	0.554	
13680	0.578	
13920	0.640	
14080	0.678	
14110	CAME TO PASSENGER	
15200	—	
16720	—	
18119	FAILURE	

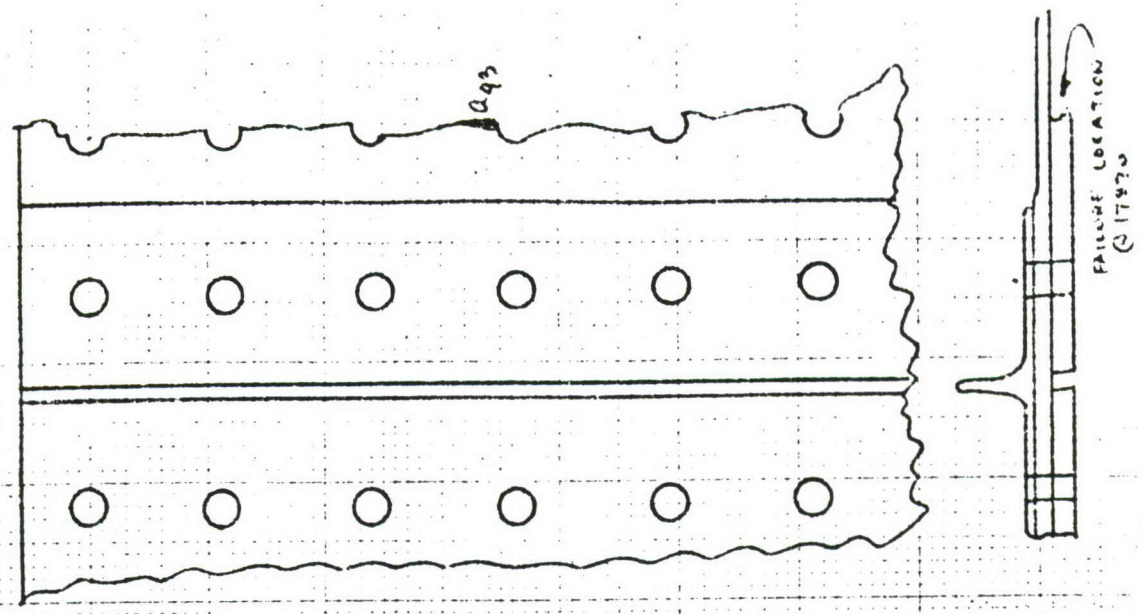
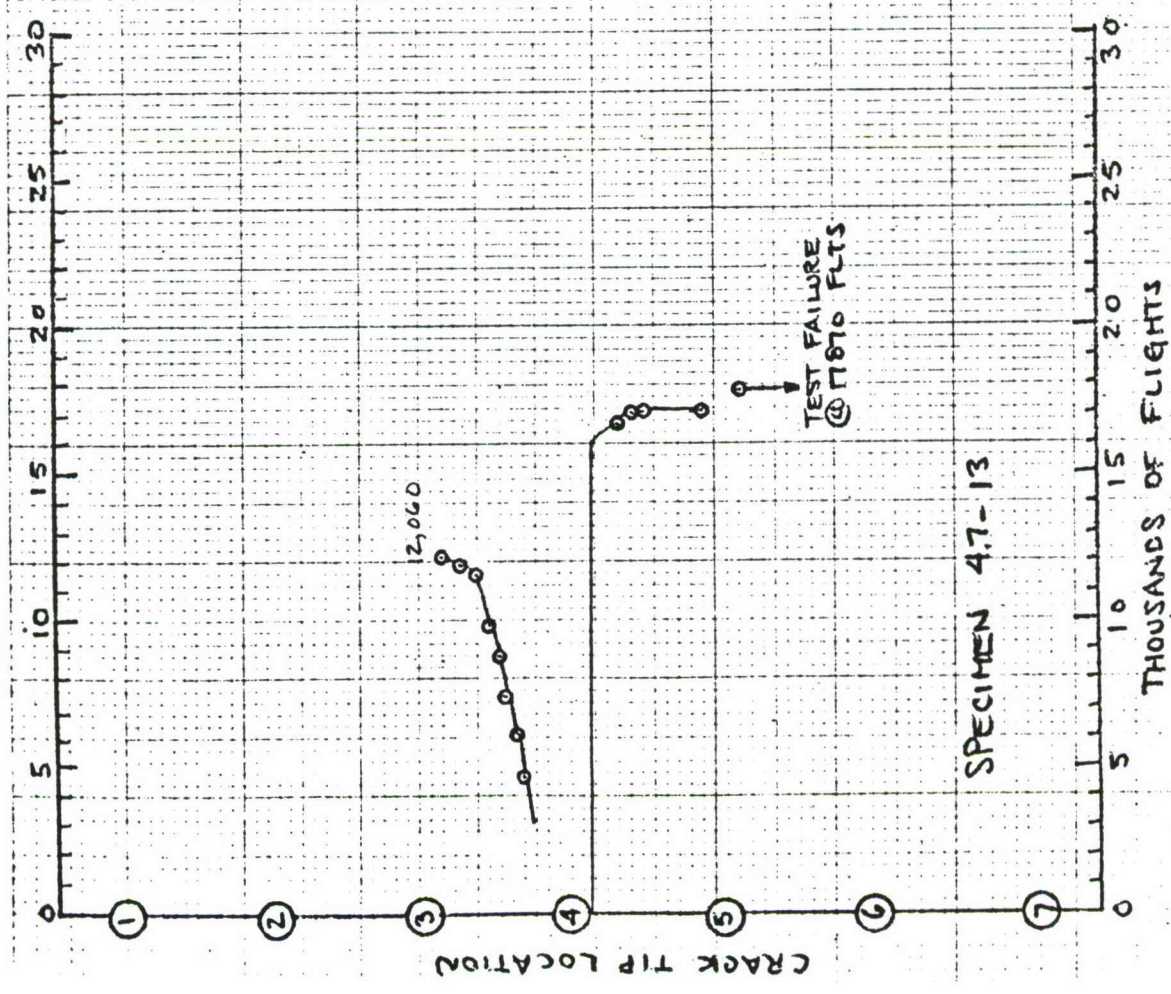


SPECIMEN 4.7-12

DATA SHEET(S): 573325-27

TEST DATE(S): 4-14-77-4-25-7

FLTS	a43	a45
7120	0.305	
7600	0.339	
7920	0.354	
8320	0.373	
8720	0.383	
9120	0.411	
9440	0.428	
9840	0.447	
10240	0.470	
10640	0.491	
10960	0.510	
11360	0.565	
12160	0.619	
12640	0.652	
13200	0.698	
13440	0.707	
13680		
14040	0.723	
14400	0.800	
14640	0.864	
14800	0.930	
14910	CRACK TO FASTENER	
15200		
16720		
18240		
19760		
20160	0.261	
20280	0.324	
20400	0.432	
20440	FAILURE	



SECTION V

TEE-REINFORCED CONTINUOUS SKIN SPECIMENS

Crack growth data and predictions for the tee-reinforced specimens with continuous skin are presented in this section. A total of twelve specimens were tested, all under constant amplitude fatigue loading at $S_{\max} = 17$ ksi, $R = 0.1$. The configurations and the initial damage are shown in Figure B-1 (Appendix B) and Table 3 of Volume I.

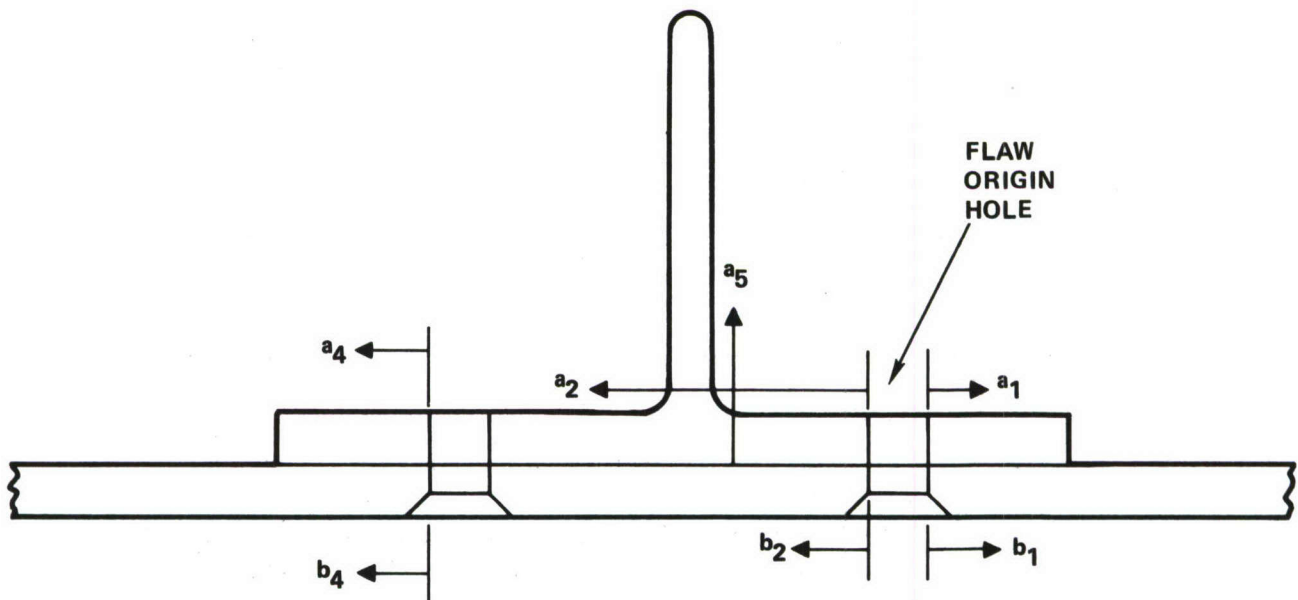
The format of data presentation is similar to the formats of previous sections, in that a graphic presentation of the crack path is added to the tabulated data shown previously. Three schematic views of the central test area of each broken specimen (a sectional view, a top view, and a side view) are shown together with the growth curves to aid in visualizing the actual crack path. The tabulated data and the graphic presentation of crack path are shown on face-to-face pages to facilitate cross reference.

The notation of a_i and b_i are still used to denote crack lengths for cracks on the head side and the collar side, respectively. In addition, the letters A, B, C, etc., are used on the sectional view to indicate locations of thin marks left on the fracture surface by the application of low-amplitude marking cycles.

A stop-drill hole was put in the skin, when necessary, about 1.6 inches from the edge of the fastener hole from which the crack was originated. The stop-drill hole was to prevent the rapid cracking of the skin and enable the accumulation of further crack growth data at the other end of the crack. A nominally 0.375-inch diameter hole was used, and a clearance fit, fully-torqued Hi-Lok fastener was placed in the hole to further retard the crack growth.

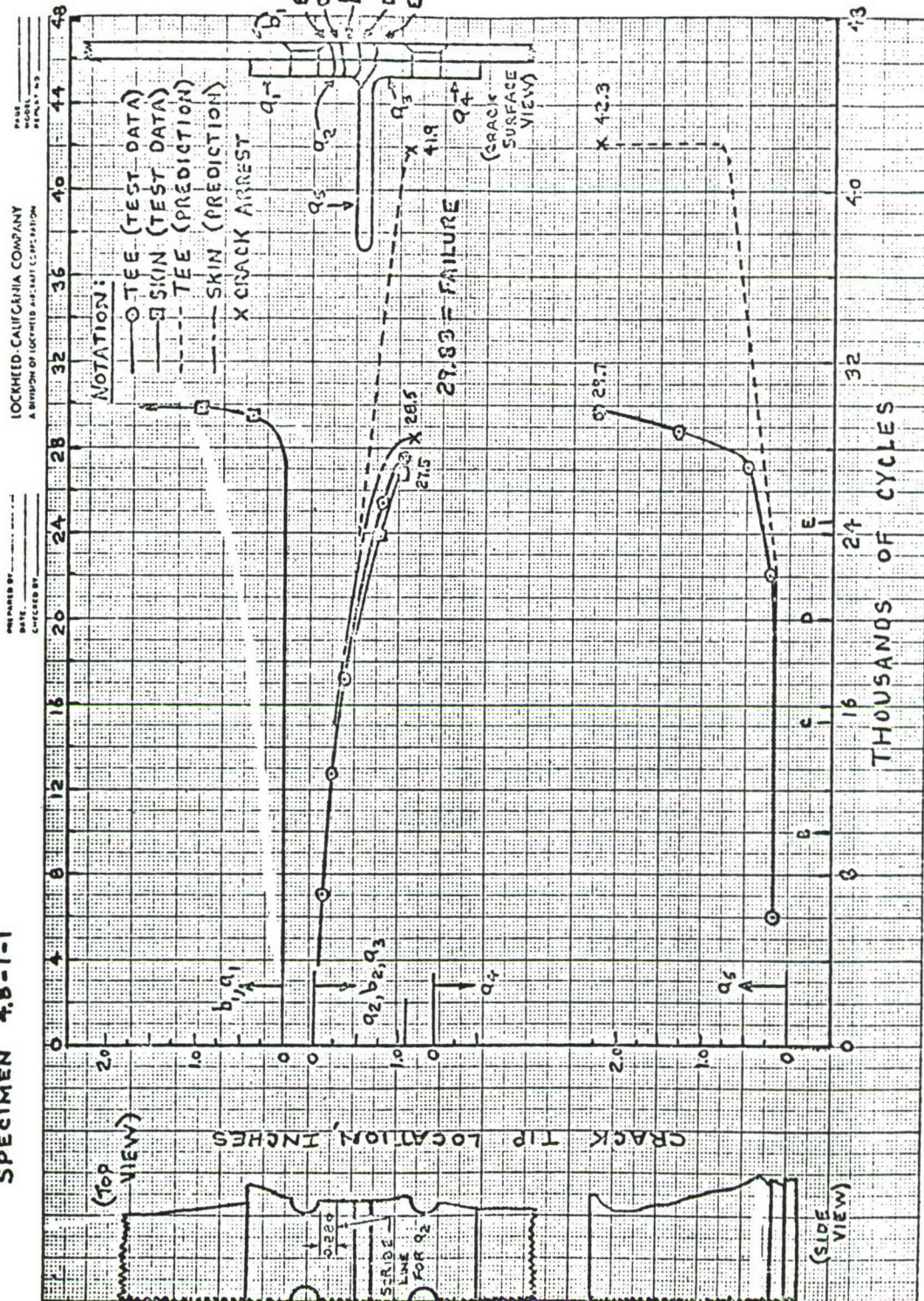
NOTES FOR ALL TEE-REINFORCED CONTINUOUS-SKIN SPECIMENS

- ① Initial crack lengths measured at faying surfaces before assembly. All other length measurements are at externally-visible surfaces.
- ② Marking cycles A, B, C, D, etc. produce thin marks on the fracture surface. (See fracture surface view on drawing.) Numbers in parentheses indicate marking cycles, $S_{\max} = 17.0$ ksi, $R = 0.83$.
- ③ In radius of tee.
- ④ Arrests at hole.
- ⑤ Under head of rivet.
- ⑥ Arrests at edge.
- ⑦ Rapid propagation to edge
- ⑧ Stop drill 0.378 diameter hole; install clearance-fit HL50-12-6 Hi-Lok fastener with steel washers in collar and 190 in.-lb torque.
- ⑨ Initial crack depth measured on fracture surface.
- ⑩ Crack dimension is on faying surface.
- ⑪ Arrests at edge. Tee fails completely.
- ⑫ Complete failure of tee.



NOTATION FOR SPECIMEN TYPE 4.8-1-X

SPECIMEN 4.8-1-1

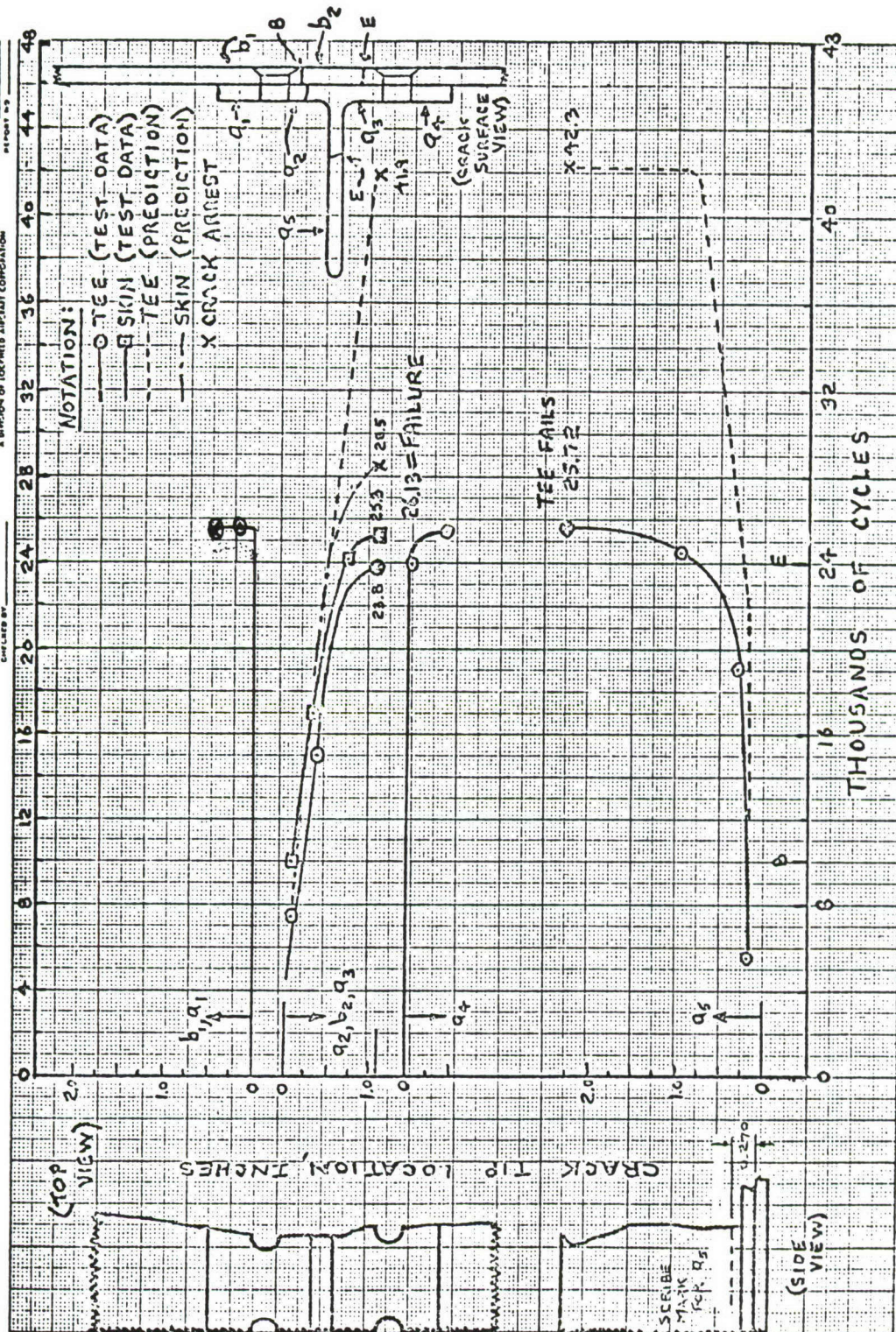


DATE TESTED
4-19-76

WORK SHEET

LOCKHEED-CALIFORNIA COMPANY
A DIVISION OF LOCKHEED AIRCRAFT CORPORATION

page _____
sheet _____
drawing # 2 _____



DATA SHEET NO. 5
570293-S, 7-9

SPECIMEN 4.8-1-2

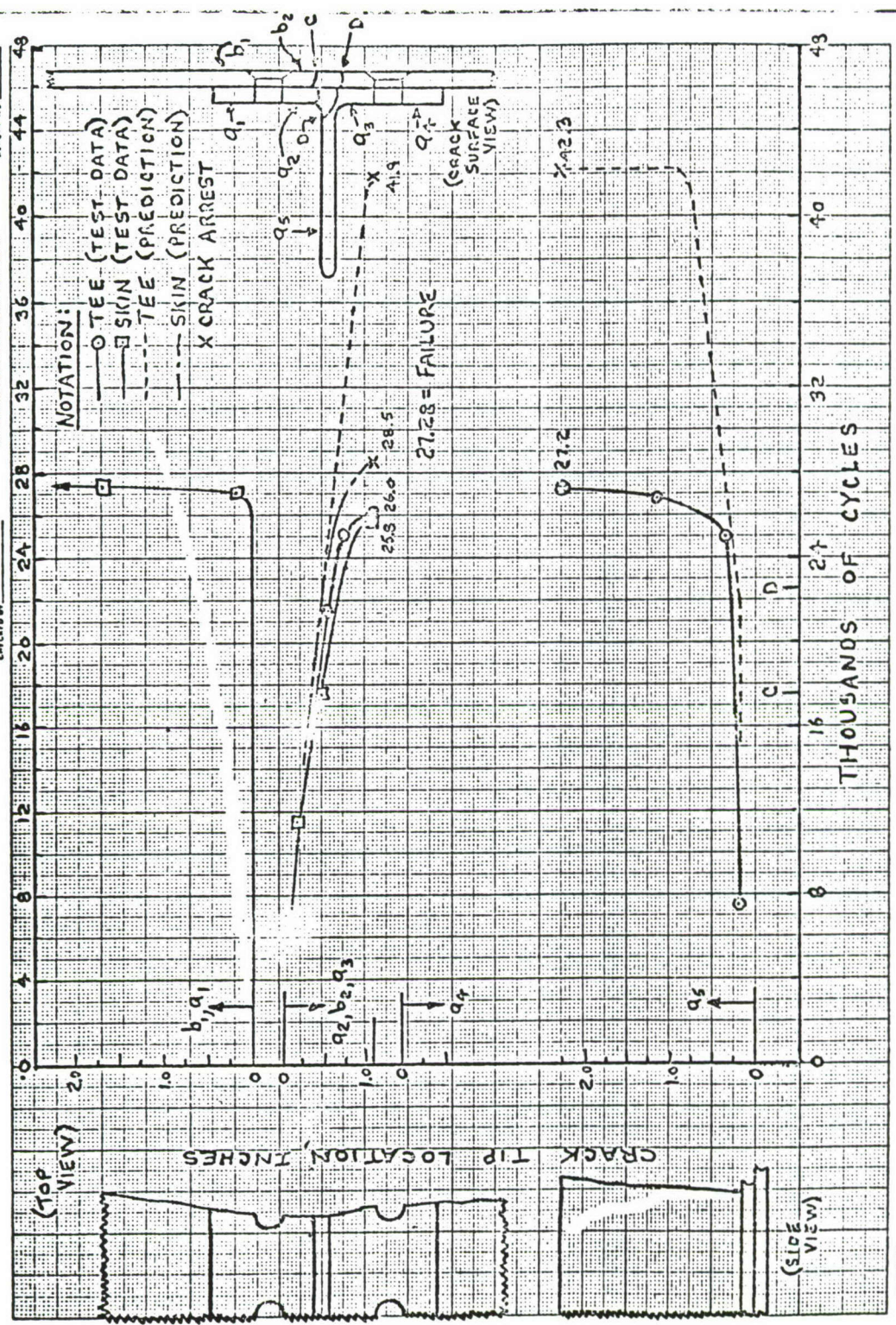
DATE TESTED
4-27-76

N	a ₂	a ₄	a ₅	b ₂	b ₄	a ₁	Strain Gage Surveys
0	.054 ^①	.022 ^①		.055 ^①	.016 ^①		1 & 2 & 3
4	DIMPLE		.190				
5	DIMPLE						
A ^② MARK (10)	DIMPLE						
5.5	.050						← 4
7.5	.130						
10	.228			.100			5
B ^② MARK (15)	—			—			
11	.265			.136			
13	.326			.176			
15	.351			.223			
C ^② MARK (10)	.351			.224			
15.5	③			.250			
17	③			.335			
19	③		.290	.395			
D ^② MARK (10)	③		—	—			← 6
22.5	.684		.460	.630			7
23.5	.857		.66	.684			
23.753	④		—	—			
24			.75	.725			8
E ^② MARK (5)			—	—			
24.5			.94	.745			
25.25			1.29	④	.192		9
25.275			1.39		⑥		10
25.565			⑥				11
25.715		⑥	⑫				12
26.125			b ₁ + b ₄ = 1.4				13
26.132			FAILURE				

LOCKHEED-CALIFORNIA COMPANY
A DIVISION OF LOCKHEED AIRCRAFT CORPORATION

PREPARED BY _____
DATE _____
CHECKED BY _____

PAGE _____
PAGE _____
REMARK NO. _____



DATA SHEET NO. 1's
569971-4

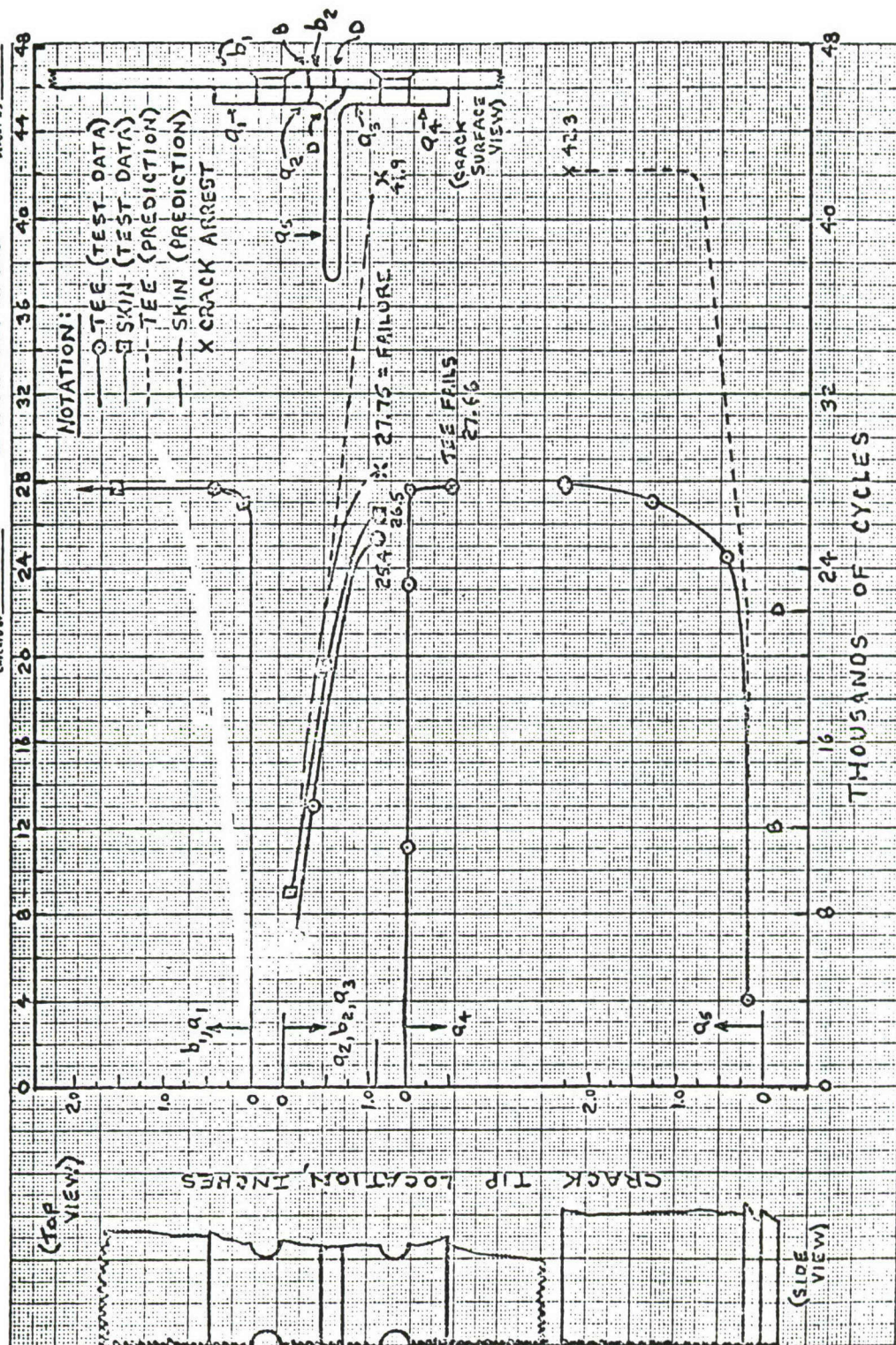
SPECIMEN 4.8-1-3

DATE TESTED
5-1-76

N	a ₁	a ₂	a ₄	a ₅	b ₁	b ₂
0		.050 ^①				.054 ^①
5.743		DIMPLE		.194		
7.5		.106				
A ^② MARK (10)						
8.5		.138				
11.5		.234				.188
12.5		.270				.223
B ^② MARK (10)		.272				.223
14.5		.337				.304
15.5		.370				.347
15.979		③				—
17.50		③				.447
C ^② MARK (10)		③				.449
22.5		③				.669
D ^② MARK (10)		③				.676
23.5		③		.280		.746
25.0		.698		.350		.868
25.7		.859		.470		1.048
25.8		.985		.510		④
26.0		④		.640		
26.8				1.140	.111	
27.0	1.48			1.310	.182	
27.052	⑥			—	—	
27.2			DIMPLE	1.770	.485	
27.238		.201	⑥	.608		
27.242		⑥		.719		
27.277				1.701		
27.282		FAILURE				

LOCKHEED-CALIFORNIA COMPANY
A DIVISION OF LOCKHEED AIRCRAFT CORPORATION

NAME _____
TITLE _____
DEPT. NO. _____



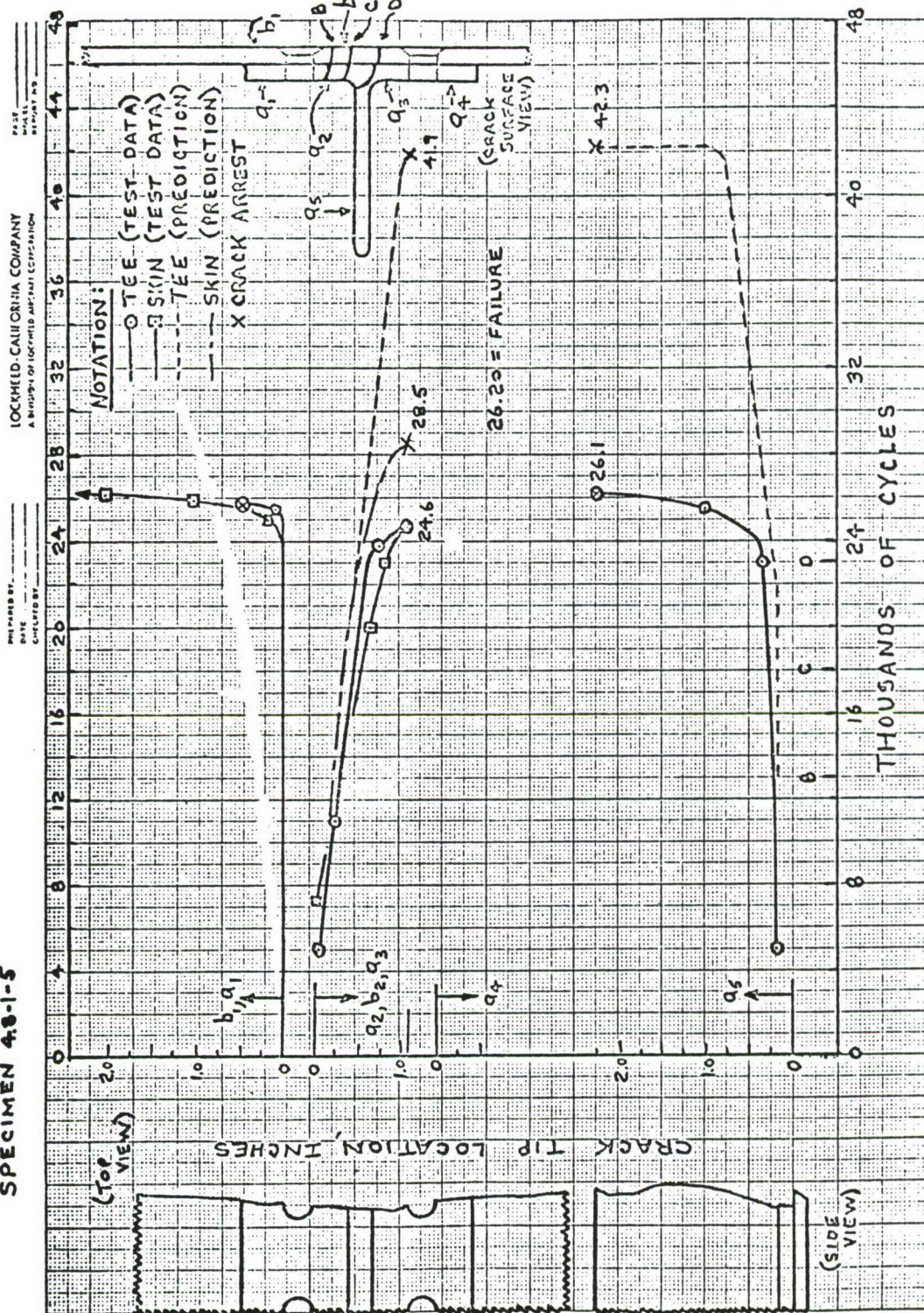
DATA SHEET NO. 5
569979-82

SPECIMEN 4.8-1-4

DATE TESTED
5-20-76

N	a ₁	a ₂	a ₄	a ₅	b ₁	b ₂
0		.084 ⁽¹⁾				.075 ⁽¹⁾
4		.040		.188		
7		.153				
A ⁽²⁾ MARK(10)		.155				
9		.212				.087
12		.303				.128
B ⁽²⁾ MARK(10)		.308				.199
13		.345				.236
15		(3)				.304
17		(3)				.382
C ⁽²⁾ MARK(10)		(3)				.383
19.5		(3)				.479
22		(3)		.310		.576
D ⁽²⁾ MARK(10)		(3)		.310		.577
24.5		.841		.430		.741
25		.955		.490		.780
25.382		1.142		.570		.830
25.392		(4)		—		—
26.401				1.01		1.120
26.5				—		(4)
27				1.29	.090	
27.4	DIMPLE			1.49	.185	
27.5	.156			1.59	.228	
27.55	.284			—	—	
27.566	(6)			—	—	
27.6				1.72	.263	
27.65		.014	(6)	.444		
27.658		(6) (12)		—		
27.723				1.522		
27.745				2.738		
27.749	FAILURE					

SPECIMEN 48-1-5



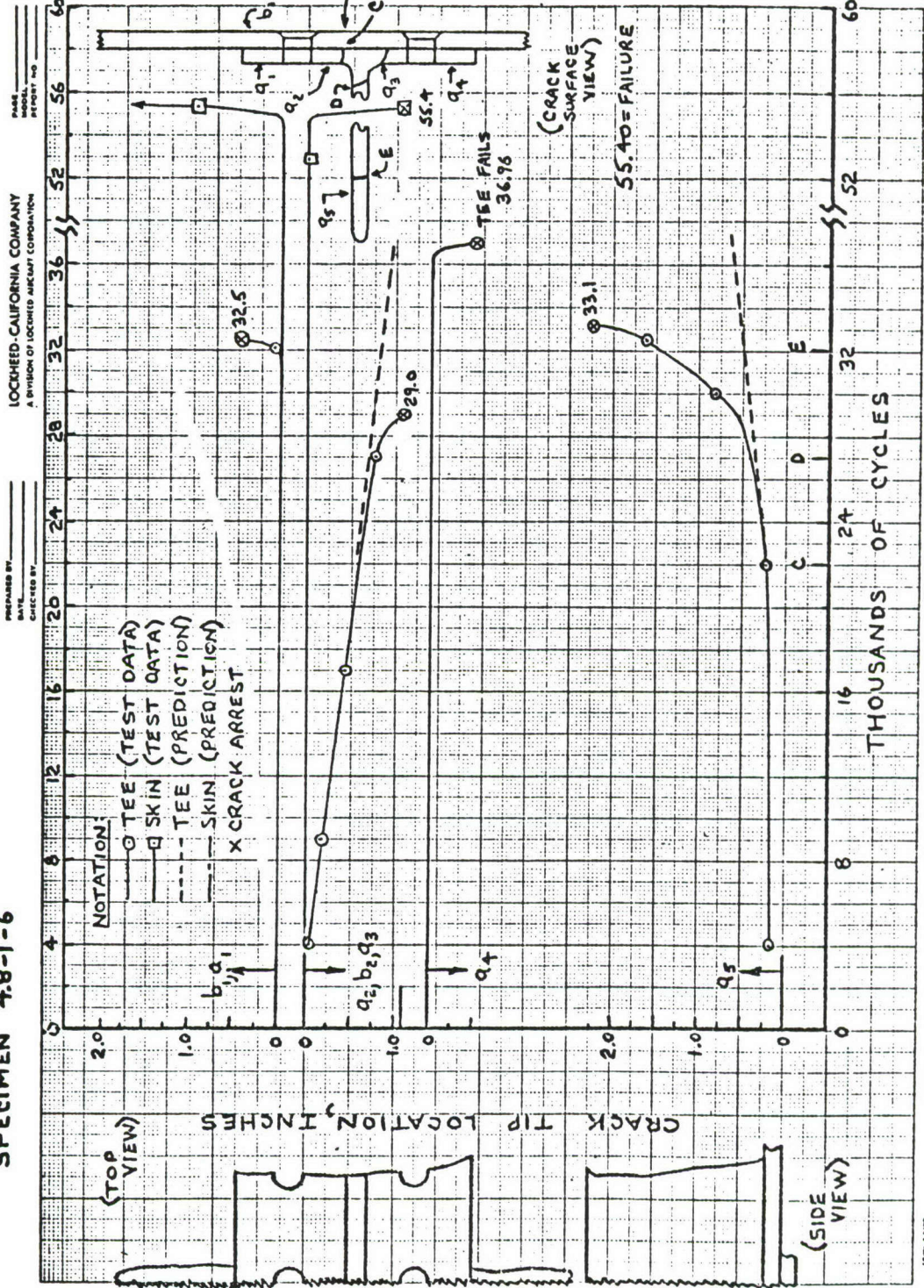
DATA SHEET NO.'S
569983-6

SPECIMEN 4.8-1-5

DATE TESTED
5-25-76

N	a ₁	a ₂	a ₄	a ₅	b ₁	b ₂
0		.058 ^①				.046 ^①
5		.040		.187		
7		.111				
8		.148				.070
A ^② MARK (10)		.150				.071
11		.247				.201
13		.325				.280
B ^② MARK (10)		.326				.283
14		.348				.333
16		(3)				.413
18		(3)				.498
C ^② MARK (10)		(3)				.507
20		(3)				.612
23		DIMPLE		.350		.794
D ^② MARK (10)		DIMPLE		—		.813
23.804		.730		.390		.896
24.352		.847		.460		.978
24.5		.898		.500		(5)
24.6		.969		.530		
24.7		(5)		.600	.101	
25			DIMPLE	.760	.169	
25.3	DIMPLE			.890	.264	
25.5	.107			.990	.357	
25.6	(6)			1.090	.466	
25.9				1.490	1.025	
26.1				1.900	1.78	
26.13				(6)	2.12	
26.186					2.90	
26.197		FAILURE				

SPECIMEN 4.8-1-6

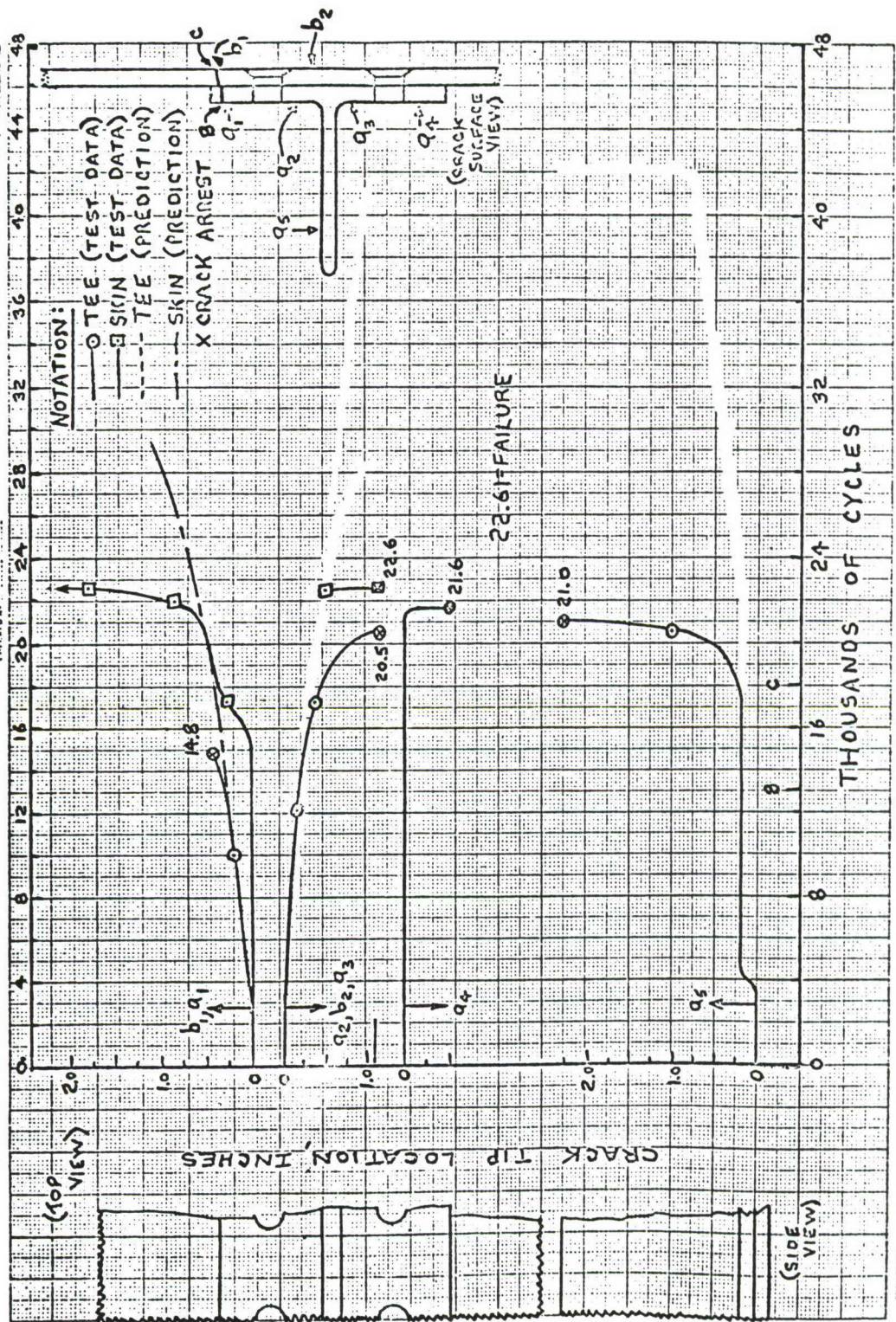


DATA SHEET NO's.:
570281 TO 285

SPECIMEN 4.8-1-6

DATES TESTED
4-13 TO 4-16-1976

N	a ₁	a ₂	a ₄	a ₅	b ₁	b ₂	b ₄
0		0.064 ⁽¹⁾		0.13 ⁽⁹⁾			
4.0		0.033		0.188			
5.0		0.076					
(2) A. MARK (15)		0.094					
6.5		0.131					
9.0		0.187					
12.0		0.278					
15.0		0.373					
17.0		0.42 ⁽³⁾		0.20			
(2) B. MARK (10)							
22.0		0.57		0.24			
(2) C. MARK (10)							
27.0		0.76		0.418			
(2) D. MARK (10)		0.80		0.43			
28.4							
29.0		1.14 ⁽⁴⁾		0.554			
30.0				0.812			
31.0				1.123			
32.0				1.449			
(2) E. MARK (10)	0.08 ⁽¹⁰⁾			1.474			
32.5	0.46 ⁽⁶⁾			1.619			
33.0				1.970			
33.128				2.25 ⁽⁶⁾			
36.959			0.50 ⁽¹¹⁾				
37.0							
(2) F. MARK (10)							
52.0							
(2) G. MARK (10)					0.05 ⁽¹⁰⁾	0.12 ⁽¹⁰⁾	
55.381					0.925	1.14 ⁽⁴⁾	0.08 ⁽¹⁰⁾
55.399	F	A	I	L	U	R	E



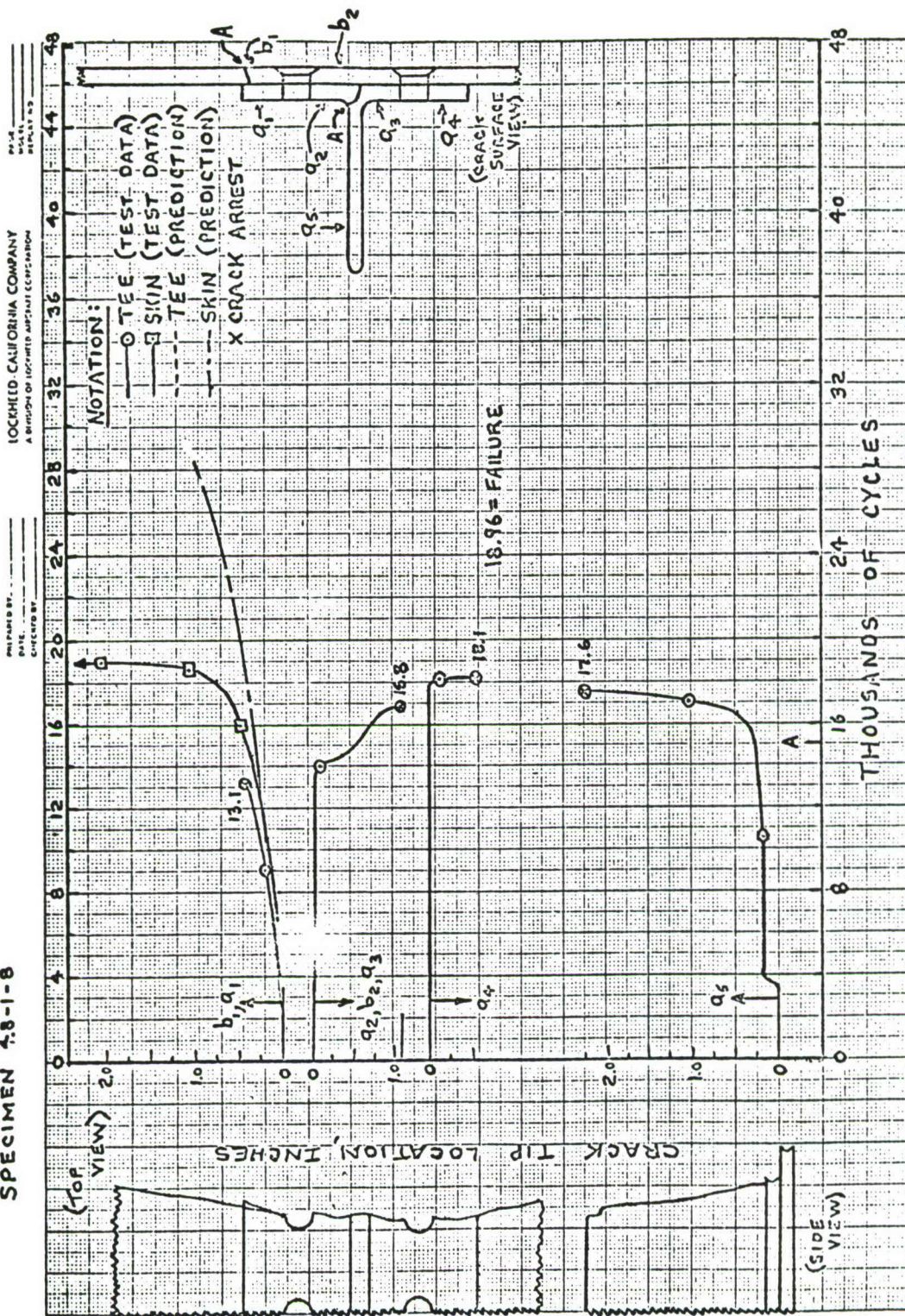
DATA SHEET No. 1's
569975-8

SPECIMEN 4.8-1-7

DATE TESTED
5-18-76

N	a ₁	a ₂	a ₄	a ₅	b ₁	b ₂
0	.062 ^①	.016 ^①			.049 ^①	
4.5	.027			.187		
5	.066					
6	.110					
8	.151					
A ^② MARK (10)	.153					
10	.206					
12.103	.260	.140				
13	.292	.165				
B ^③ MARK (10)	.320	.167				
14	.365	.205				
14.8	.448	.231				
14.83	⑥	-				
16.5		.288			.005	
16.8		.306			.181	
17.3		.374			.272	
18		③			.360	
C ^② MARK (10)		③			.368	
19.25		③		.370	.437	
19.8		DIMPLE		.440	.464	
20.5		④		1.01	.512	
20.9				1.49	.562	
21.				1.66	.582	
21.089				⑥	.596	
21.202			DIMPLE		-	
21.628		.15			.685	
21.640		⑥			.694	
22.1					.994	
22.4					1.35	
22.591					1.78	.50
22.6					2.22	④
22.606						FAILURE

SPECIMEN 4.3-1-8



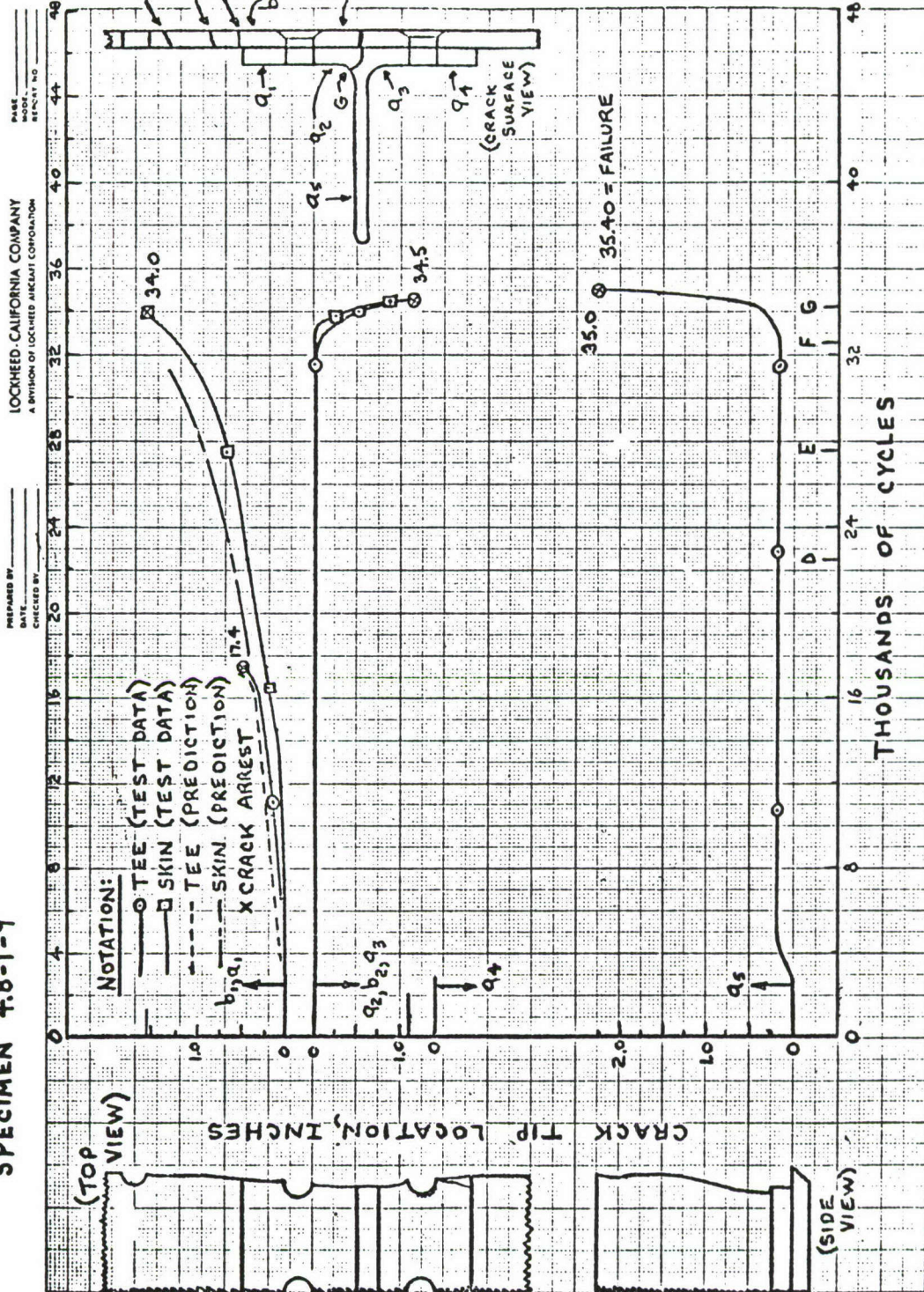
DATA SHEET NO. 5
569957-60

SPECIMEN 4.8-1-8

DATE TESTED
5-10-76

N	a ₁	a ₂	a ₄	a ₅	b ₁
0	.056 ^①	.021 ^①			.050 ^①
4	.028			.187	
5	.071				
6.5	.128				
7.5	.156				.002
8	.174				.062
9	.217				.108
10	.235				.147
12	.322				.230
13	.373				.273
13.085	(6)				—
14		.100			.320
14.5		.365			.345
15.		(3)			.375
A ^② MARK (10)		(3)			.385
16		(3)		.360	.464
16.5		.846		.490	.508
16.741		1.136		.670	.525
17.		(4)		1.07	.554
17.5				1.83	.624
17.587			DIMPLE	(6)	.651
18.133			.112		.749
18.149			(6)		.768
18.6					1.078
18.8					1.319
18.95					2.050
18.957	FAILURE				

SPECIMEN 4.8-1-9



DATA SHEET NO.'S
569966-70

SPECIMEN 4.8-1-9

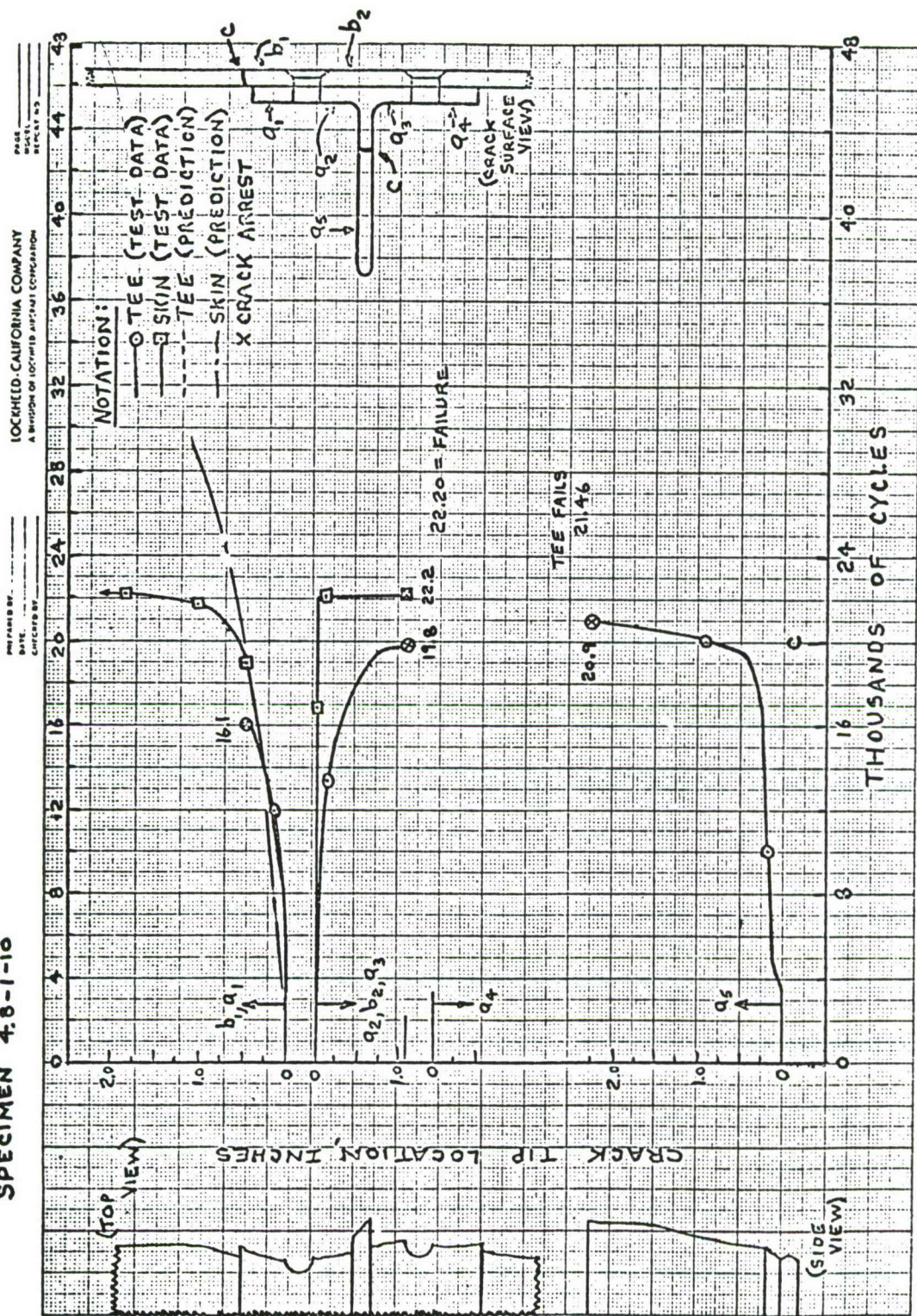
DATE TESTED
5-12-76

N	a ₁	a ₂	a ₄	a ₅	b ₁	b ₂
0	.055 ^①				.052 ^①	
5	DIMPLE			.188		
7.5	.086					
A ^② MARK (10)	.091					
10.5	.156					
12.5	.200					
B ^② MARK (10)	.207					
14.5	.265				.127	
16.5	.330				.199	
17.408	.428				.228	
17.448	(6)				—	
17.5					.229	
C ^② MARK (10)					—	
18.5					.270	
22.5					.426	
D ^② MARK (10)					.434	
27.5					.694	
E ^② MARK (10)					.698	
31.6		.024			1.083	
32.5		.047			1.197	
F ^② MARK (10)		.060			1.230	
33.8		.338			1.502	.282
34		(3)			1.618(8)	.390
34.2		(3)				.560
G ^② MARK (5)		(3)				.605
34.25		(3)		.510		.668
34.4		(3)		.590		.886
34.45		DIMPLE		.610		(4)
34.55		.964		.750		
34.561		1.145		—		
34.571		(4)		—		
34.6				.980		
34.8				1.570		
34.978			DIMPLE	2.070		
35.			DIMPLE	2.150		
35.014			DIMPLE	(6)		
35.048			(6)			
35.4			FAILURE			

FORM LAC 38

WORK SHEET

SPECIMEN 4.8-1-10



DATE TESTED
4-21-76

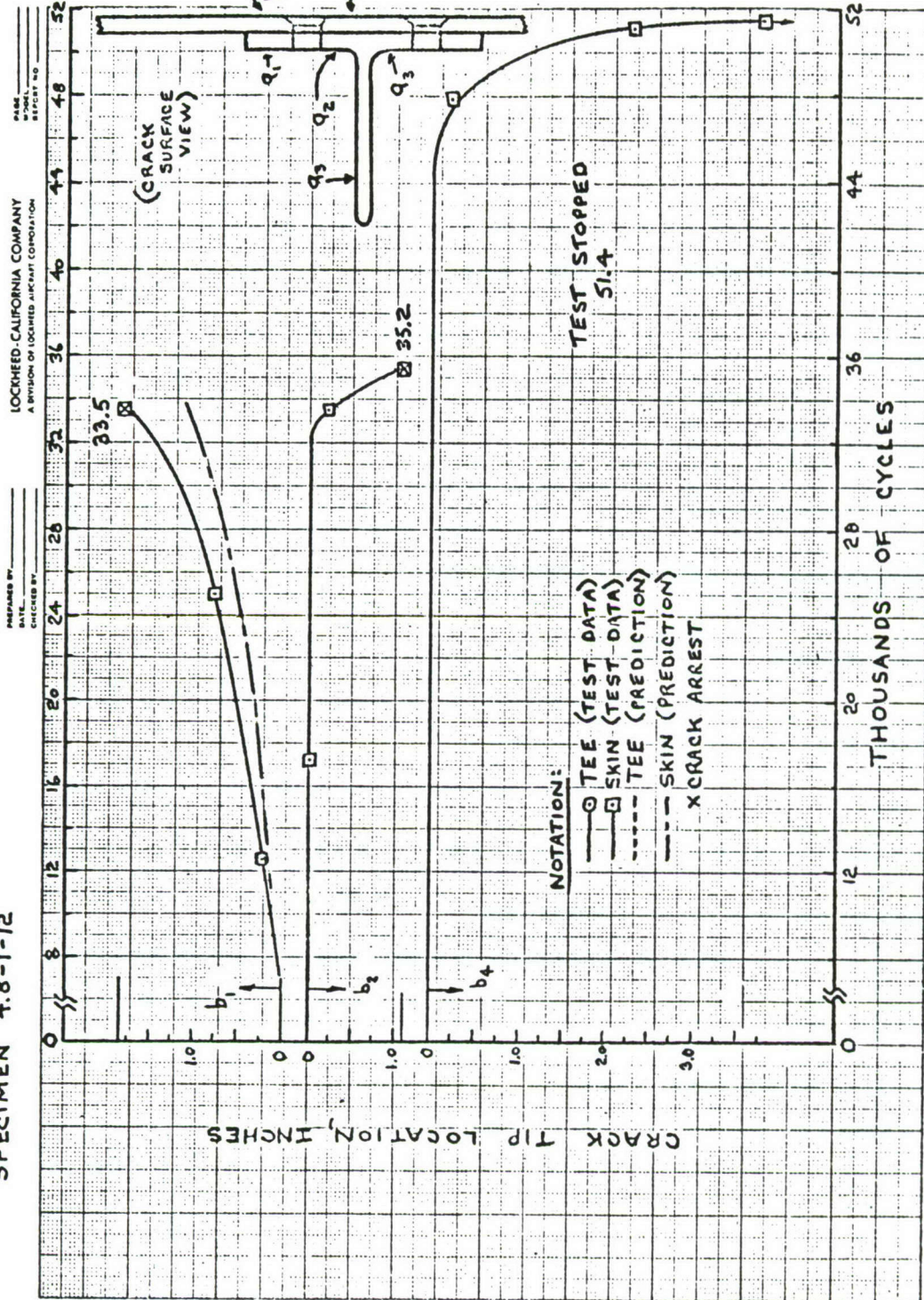
*A tunneled dark area, usually the evidence of a tensile overload, is present at Mark B on a₁ and a₂. A much thinner, non-tunneled dark line is present on b₁, also at Mark B. However, no record of overload or other abnormal test condition existed at that time.

DATA SHEET NO. 15
569961-S

SPECIMEN 4.8-1-11

N	a ₁	a ₂	a ₅	b ₁	b ₂	b ₄
0	.062 ⁽¹⁾			.055 ⁽¹⁾		
4.5	.036		.187			
5.5	.079					
7	.134					
7.5	.148			.030		
8.	.165			.082		
A ⁽²⁾ MARK (10)	—			—		
8.5	.178			.109		
11	.279			.198		
12.458	.417			.251		
12.459	(6)			—		
13				.282		
B ⁽²⁾ MARK (10)				—		
14				.338		
17				.551		
C ⁽²⁾ MARK (10)				.572		
20				.774		
22				.912		
D ⁽²⁾ MARK (5)				.929		
23				1.030		
26		.358		1.400		
26.703		(3)		1.636 ⁽⁸⁾	.131	
E ⁽²⁾ MARK (5)		(3)	.287		.180	
27		(3)	.427		.393	
27.05		.848	.437		.459	
27.2		1.063	.637		.749	
27.25		(5)	.837		(5)	
27.4			1.337			
27.55			1.837			
27.6			(6)			
F ⁽²⁾ MARK (2.5)						
28.518					.40	
28.522			FAILURE			

SPECIMEN 4.8-1-12



DATA SHEET No. 3
569951-6

SPECIMEN 4.8-1-12

DATE TESTED
5-6-76

N	b ₁	b ₂	b ₄
0	.062 ^①		
7.5	.039		
9	.101		
10	.131		
A ^② MARK (10)	—		
12.5	.231		
15	.318		
B ^② MARK (10)	—		
20	.527		
C ^② MARK (10)	.532		
25	.782		
D ^② MARK (10)	.790		
30	1.168		
E ^② MARK (7)	1.197		
33	1.652		
33.5	1.806 ^③	.210	
34		.330	
34.25		.497	
35		.849	
35.15		⑤	
47.85		.21	
48.15		.292	
F ^② MARK (5)		.311	
48.75		.543	
49.25		.769	
G ^② MARK (5)		.815	
50.25		1.160	
50.75		1.658	
51.05		2.310	
51.25		2.800	
51.35		3.750	
51.395		⑥	
51.445	TEST STOPPED		

SECTION VI

TEE-REINFORCED SPLIT-SKIN SPECIMENS

Data and predictions are presented in this section for the 14 tee-reinforced split-skin specimens. The configuration and initial damage conditions are summarized in Figure B-1 (Appendix B) and Tables 3 and 4 of Volume I.

The format of data presentation is nearly identical to that of the preceding section, with minor differences in the notation and notes.

Specimens 4.8-3-1 and -2 were 80-flight Spectrum tested. Simplified crack growth life predictions were made for these specimens based upon corresponding constant amplitude data, but no detailed prediction of crack sequence was done.

NOTES FOR ALL SPLIT-SKIN SPECIMENS

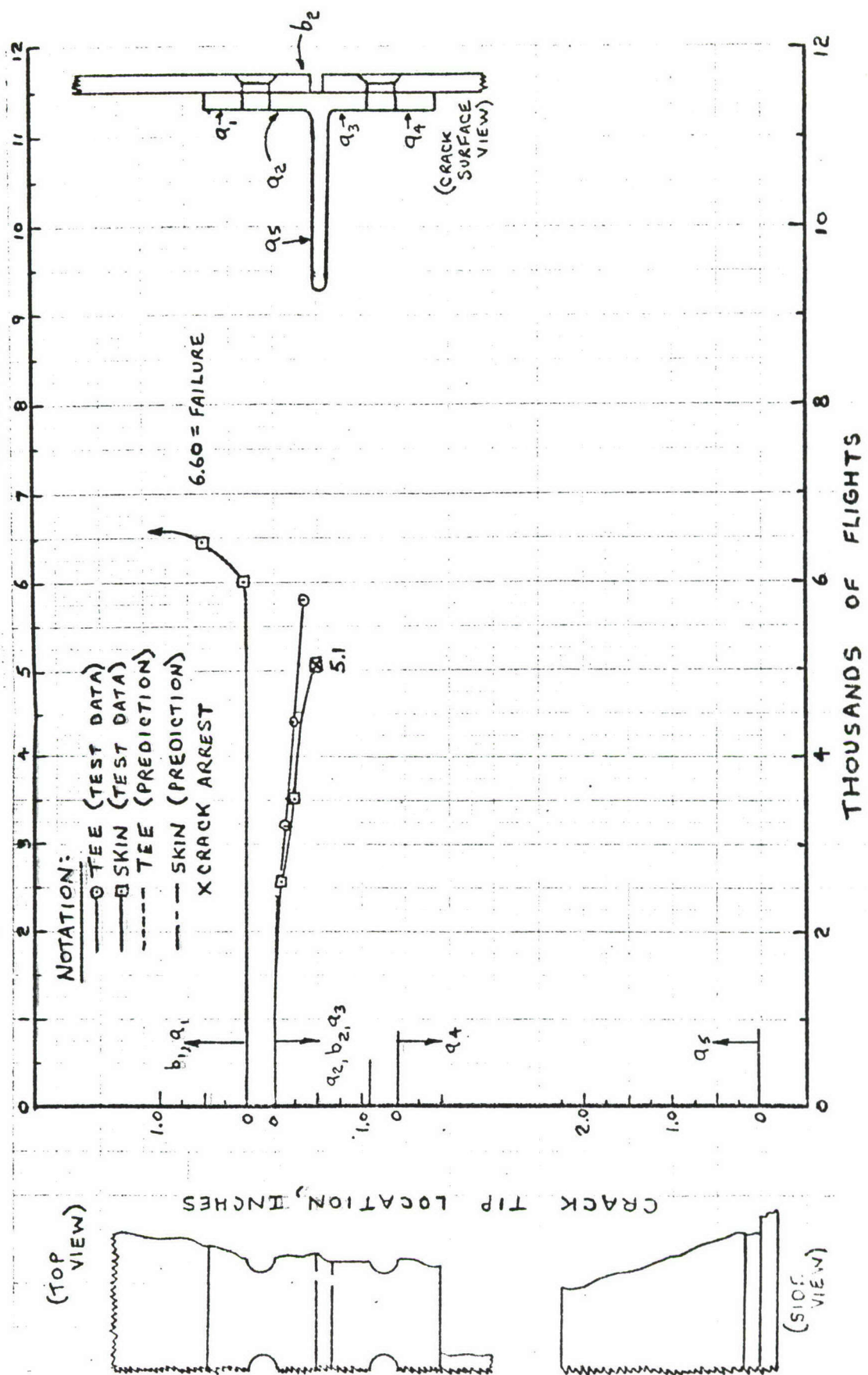
- ① Initial crack lengths measured at faying surface before assembly. All other length measurements are at externally-visible surfaces.
- ② Initial crack depths measured on fracture surface after test.
- ③ Crack reaches fillet radius.
- ④ Viewed through gap between skin pieces. (Faying surface length)
- ⑤ a_3 measured from edge of hole, like a_2 . Measurements include the distance to scribe mark, where crack broke through protruding leg of tee.
- ⑥ Arrests at hole.
- ⑦ Arrests at edge.

- ⑧ Arrests at edge. Tee breaks completely.
- ⑨ a_5 measured from faying surface. Measurements include the distance up to scribe mark used for reference during the test.
- ⑩ Stop drill 0.378-inch hole; install clearance-fit HL50-12-6 Hi-Lok fastener with steel washers under collar and 190 in-lb. torque.
- ⑪ No visual detection during test. Measured on fracture surface after test. (Marking cycle mark is evident.)
- ⑫ Marking cycles A, B, C, D produce thin marks on the fracture surface. (See fracture surface view on drawing.) Numbers in parentheses indicate 5,000 or 10,000 marking cycles. $S_{\max} = 17.0$ ksi, $R = 0.82$.
- ⑬ Popping noises just prior to crack measurement. (4.8-3-7)
- ⑭ Failure of loading stud (4.8-3-5)
- ⑮ Crack at interference-fit fully-torqued fastener measured from edge of collar (D = inch) or edge of head (D = inch).
- ⑯ Crack disappears under collar of fastener.
- ⑰ Razor-blade-induced continuing damage flaws. These are mechanical flaws simulating a 0.005-inch fatigue-induced corner crack.
- ⑱ Corner crack on faying surface, seen on fracture surface after test (spec. 4.8-3-9 and 4.8-3-13).
- ⑲ Length at faying surface.
- ⑳ Length of b_1 , including stop-drill hole.
- ㉑ No recorded data on a_1 , but fatigue cracking evident on fracture surface (spec. 4.8-3-14).
- ㉒ Protruding leg of Tee broke near grip area.

SPECIMEN 4:8-3-1

LOCKHEED CALIFORNIA COMPANY

1950



SPECIMEN 4.8-3-1

THOUSANDS OF FLTS.	a_1	a_2	a_5	b_1	b_2	DEPTH OF b_2
0		0.050 ⁽¹⁾	0.07 ⁽²⁾		0.041 ⁽¹⁾	0.05 ⁽²⁾
2.4		0.028				
2.48		0.051				
2.56		0.072			0.098	
2.72		0.094			0.136	
2.96		0.117			0.170	
3.2		0.141			0.199	
3.52		0.164			0.231	
4.4		0.209			0.292	
5.08		0.269			0.46 ⁽⁷⁾	
5.80		0.313				
5.92		(3)				
6.04				0.060		
6.20				0.194		
6.28				0.293		
6.36				0.453		
6.44				0.525		
6.52		0.52 ⁽²¹⁾	0.29 ⁽²¹⁾	0.643		
6.599	F	A	I	L	U	R E



DATA SHEET NO.'s
573601 TO 604

SPECIMEN 4.8-3-2

DATES TESTED:
9-20 TO 9-27-1976

THOUSANDS OF FLIGHTS	a ₁	a ₂	a ₃	a ₄	a ₅	b ₁	b ₂	b ₃	BLOCKS BEFORE FAILURE
0		0.046 ⁽¹⁾					0.045 ⁽¹⁾		
2.64		0.022							
2.72		0.039							
2.88		0.079							
3.04		0.111							
3.28		0.142							
3.32 (22)		—							
3.6		0.171					0.095		
3.76		0.181					0.132		
4.16		0.213					0.167		
4.64		0.248					0.225		
5.04		0.272					0.242		
5.44		0.320					0.288		
5.68		0.349					0.325		
6.08		0.376					0.48 ⁽⁷⁾		- 36.5
6.48		0.474							- 31.5
6.88		0.505							- 26.5
7.36		0.537				0.028			- 20.5
7.6		0.567				0.065			- 17.5
7.68						0.102			- 16.5
7.76						0.148			- 15.5
7.84		0.583				0.219			- 14.5
7.92						0.304			- 13.5
8.0		0.596			0.32	0.421			- 12.5
8.24		0.636			0.41	1.06 ⁽²⁰⁾			- 9.5
8.40	0.048		0.68		0.46	↑			- 7.5
8.439	0.46 ⁽⁷⁾		1.06 ⁽⁶⁾		0.74	↑			- 7.0
8.48					0.83	↑			- 6.5
8.56				0.020	1.14	↑			- 5.5
8.64				0.052	1.45	↑			- 4.5
8.679					2.25 ⁽⁷⁾	↑			- 4
8.72				0.110		↑			- 3.5
8.759				0.46 ⁽⁸⁾		↑			- 3
8.919						↓			- 1
8.96						1.06 ⁽²⁰⁾		0.096	- 0.5
8.999	F	A	I	L	U	R	E		0

LOCKHEED CALIFORNIA COMPANY
A DIVISION OF LOCKHEED CORPORATION



DATE TESTED
6-1-1976

N	a ₁	a ₂	a ₃	a ₄	a ₅	b ₁	b ₂	DEPTH OF b ₂
0		0.066 ⁽¹⁾			~0.115 ⁽²⁾		0.052 ⁽¹⁾	~0.05 ⁽²⁾
5.0		0.062			0.188			
6.0		0.101					0.040	0.182
7.0		0.140					0.053	
A ⁽¹²⁾ MARK (10)		0.150					0.053	
10.0		0.251					0.159	
12.0		0.333 ⁽³⁾			0.188		0.210	
B ⁽¹³⁾ MARK (10)		—					0.21	
13.0		0.365					0.264	
14.0							0.306	
15.6							0.420	
15.79							0.48 ⁽⁷⁾	
17.0		0.54 ⁽⁴⁾			~0.27 ⁽⁹⁾			
C ⁽¹²⁾ MARK (10)		0.58 ⁽⁴⁾						
18.0					0.30			
20.0			0.71 ⁽⁵⁾		0.36			
20.6			0.774		0.40			
21.0			0.846		0.44			
21.5			1.10 ⁽⁶⁾		0.56			
22.0					0.84			
23.0					1.31			
23.681					1.92			
23.691	0				2.25 ⁽⁷⁾			
23.93	0.075							
23.938	0.178							
23.943	0.45 ⁽⁷⁾							
23.978								
24.0								
24.05								
24.1								
24.117								
24.130	F	A	I	L	U	R	E	

[illegible]

DATA SHEET NO's
569702-706

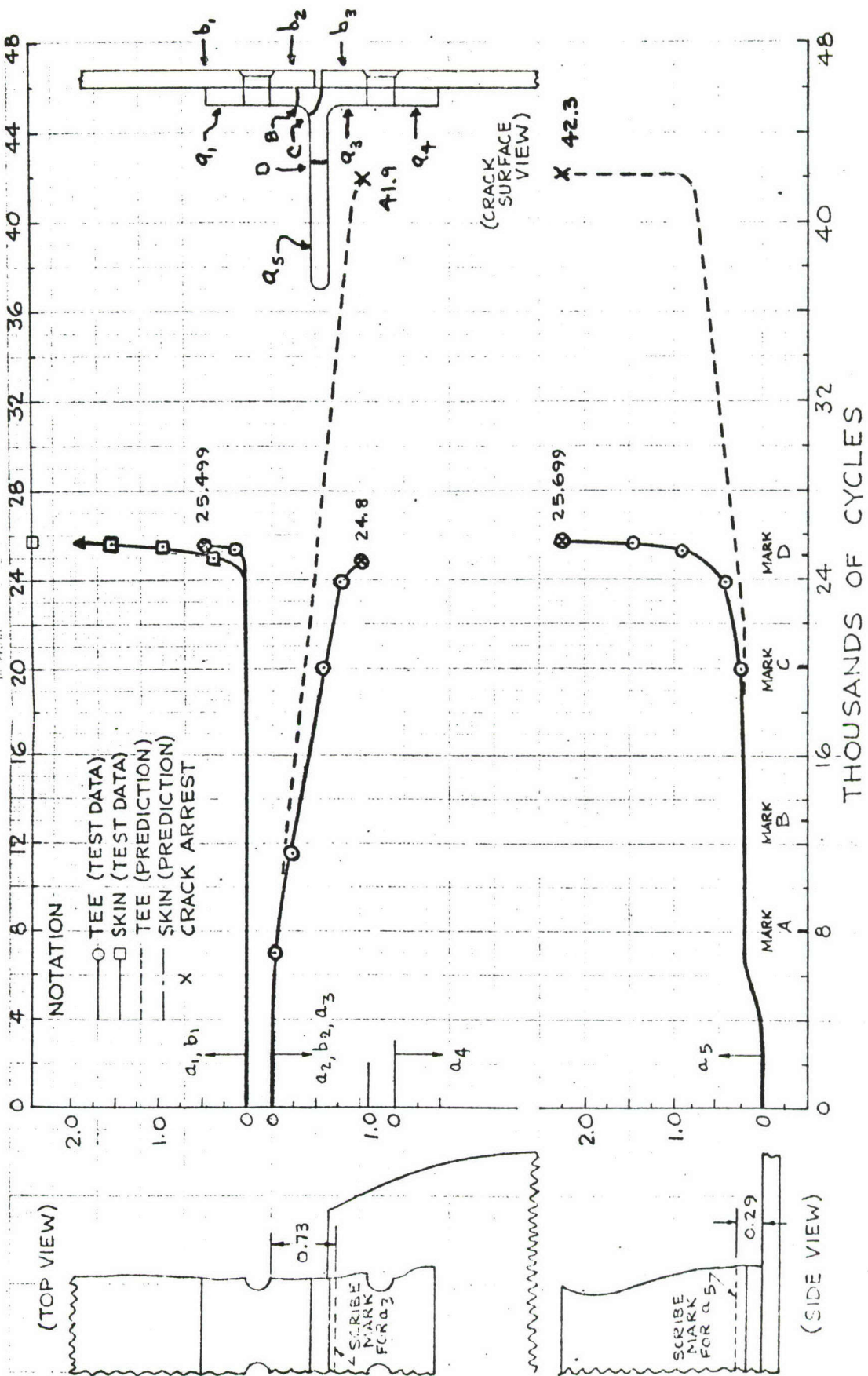
SPECIMEN 4.8-3-4

DATES TESTED:
6/9 TO 6/10/76

N	a ₁	a ₂	a ₃	a ₄	a ₅	b ₁	b ₂		
0		0.042 ^①					0.037 ^①		
5.5		DIMPLE							
6.5		0.048							
7.0		0.073							
^⑫ A. MARK (10)		0.083							
9.0		0.156					0.137		
10.5		0.214					0.208		
12.0		0.271					0.282		
^⑬ B. MARK (10)		0.282					0.292		
13.5		0.333 ^③					0.391		
14.0							0.46 ^⑦		
17.4		0.56 ^④							
^⑬ C. MARK (10)		0.58 ^④							
19.4					0.33				
20.5			0.73		0.39				
21.0			0.836		0.44				
21.3			0.958		0.50				
21.4			1.075 ^⑥		0.56				
21.7					0.70				
22.4					0.98				
^⑫ D. MARK (5)					1.00	0.067			
22.7					1.13	0.141			
23.0					1.26	0.297			
23.3					1.42	0.521			
23.4	DIMPLE				-	-			
23.553	0.050				1.58	0.780			
23.575	0.112				1.62	0.825			
23.596	0.48 ^⑥				1.67	0.945			
23.624					1.78	1.152			
23.640					1.85	1.208			
23.653					1.94	1.320			
23.661					2.25 ^⑦	1.421			
23.67				DIMPLE		1.605			
23.685				DIMPLE		2.28			
23.695		F	A	I	L	U	R	E	

SPECIMEN 4.8-3-5

LOCKHEED-CALIFORNIA COMPANY
A DIVISION OF THE LOCKHEED CORPORATION



DATA SHEET NO.'s:
569707 TO 711

SPECIMEN 4.8-3-5

DATES TESTED:
6/11 TO 6/17/76

N	a ₁	a ₂	a ₃	a ₄	a ₅	b ₁	b ₂		
0		0.047 ⁽¹⁾			0.065 ⁽²⁾		0.040 ⁽¹⁾		
6.3		DIMPLE							
7.0		0.049							
8.0		0.099							
A ⁽¹²⁾ MARK (10)		0.105							
9.5		0.165							
11.5		0.224					—		
13.0		0.277					0.128		
B ⁽¹²⁾ MARK (10)		0.279					0.135		
14.0		0.310					0.170		
15.5		0.351 ⁽³⁾					0.226		
17.0							0.280		
18.7		0.510 ⁽⁴⁾					0.379		
19.3		0.539 ⁽⁴⁾					0.475 ⁽⁷⁾		
20.0		0.571 ⁽⁴⁾			0.26 ⁽¹¹⁾				
C ⁽¹²⁾ MARK (10)									
20.105 ⁽¹⁴⁾									
22.0					0.33 ⁽⁹⁾				
23.0					0.37				
23.882			0.786		0.42				
24.0			0.819						
24.2			0.864		0.47				
24.4			0.909		0.49				
24.6			0.934		0.54				
24.8			1.07 ⁽⁶⁾						
25.0					0.73	0.395			
D ⁽¹²⁾ MARK (10)					0.79	0.575			
25.2					0.91	0.690			
25.4	DIMPLE				1.03	0.790			
25.457	0.125								
25.478	0.204								
25.499	0.48 ⁽⁷⁾				1.15	0.945			
25.6					1.45	1.55			
25.66					1.65	2.055			
25.69					1.83	2.44			
25.699				DIMPLE ⁽¹⁵⁾	2.25 ⁽⁷⁾	2.575			
25.71				DIMPLE ⁽¹⁵⁾		2.78			
25.717			F	A	I	L	U	R	E

Journal of Interpersonal Violence

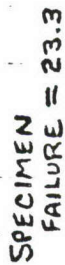


DATA SHEET NO. 5:

SPECIMEN 4.8-3-6

DATE TESTED:

N	a ₁	a ₂	a ₃	a ₄	a ₅	b ₁	b ₂		
0		0.059 ⁽¹⁾			0.1 ⁽²⁾				
4.5		DIMPLE							
5.0		0.046							
5.9		0.097							
7.0		0.135							
A. MARK(10)		0.139							
8.5		0.194							
10.5		0.258							
13.0		0.332							
B. MARK(10)		(3)							
18.0		0.534 ⁽⁴⁾							
19.0		0.570 ⁽⁴⁾							
C. MARK(10)		0.575 ⁽⁴⁾							
21.0					0.31 ⁽⁹⁾				
23.8			0.756		0.40				
24.2			0.828		0.43				
24.7			0.926		0.48				
25.0			(16)		0.56				
D. MARK(10)					0.58				
26.0					0.90				
27.0					1.10				
28.0					1.42				
28.439	0.115				1.72				
28.5	0.152				1.84				
28.581	0.47 ⁽⁷⁾				2.25 ⁽⁷⁾				
38.5							0.170		
38.8							0.309		
39.01							0.495 ⁽⁷⁾		
39.033 ⁽¹³⁾						0.239			
39.091						0.440			
39.125						0.601			
39.169						0.857			
39.224						1.277			
39.294						1.806			
39.319						2.205			
39.327						2.740			
39.333						3.640			
39.335									
		F	A	I	L	U	R	E	



DATA SHEET NO.'S
569991-995

SPECIMEN 4.8-3-7

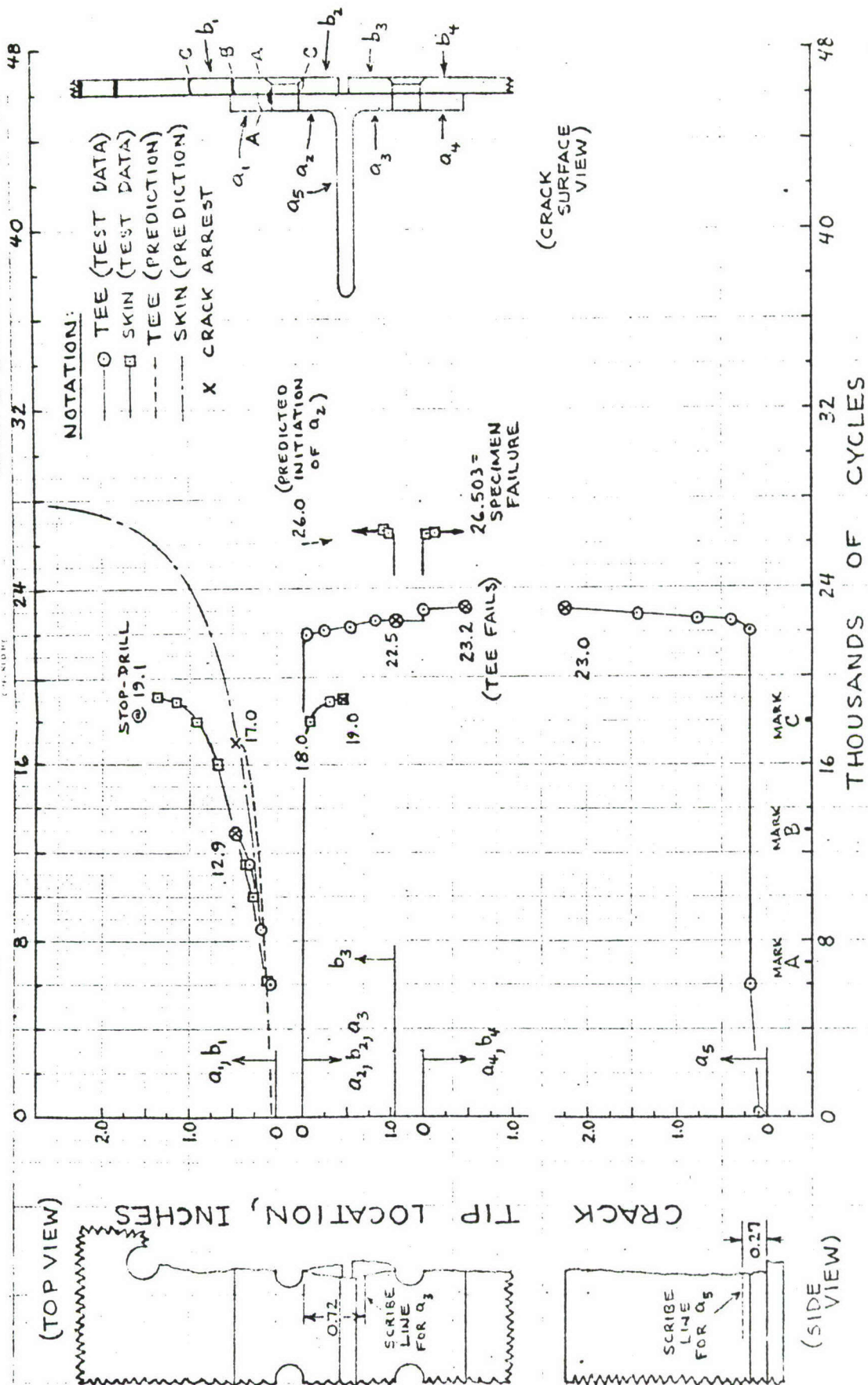
DATES TESTED:
6/2 TO 6/7/76

N	a ₁	a ₂	a ₃	a ₄	a ₅	b ₁	b ₂	b ₃	b ₄
0									
5.0	0.047								
6.0	0.088					0.072			
7.0	0.119					0.124			
A. ⁽¹²⁾ MARK(10)	0.128					0.135			
8.0	0.163					0.208			
9.5	0.217					0.300			
11.5	0.289					0.426			
13.016	0.445 ⁽⁷⁾					0.526			
13.5						0.562			
B. ⁽¹²⁾ MARK(5)						0.578			
15.5						0.743			
17.5						0.984	0.085		
18.0						1.106	0.288		
18.118						1.167	0.46 ⁽⁷⁾		
18.5						1.464			
18.8						1.800			
19.081						2.18 ⁽¹⁰⁾			
19.1									
C. ⁽¹²⁾ MARK(10)		⑪			SCRIBE @ 0.25"				
19.576 ⁽¹³⁾		③	⑥		0.90				
19.6					1.05				
19.64					1.19				
19.66					1.29				
19.7					1.41				
19.72					1.49				
19.74					1.57				
19.76					1.66				
19.78					1.79				
19.8					1.89				
19.808					2.25 ⁽⁷⁾				
19.908					0.47 ⁽⁸⁾				
23.24								DIMPLE	DIMPLE
23.254		F	A	I	L	U	R	E	

SPECIMEN 4.8-3-8

PROPERTY
TEST
C. M. NOLTE

LOCKHEED-CALIFORNIA COMPANY
A DIVISION OF LOCKHEED CORPORATION

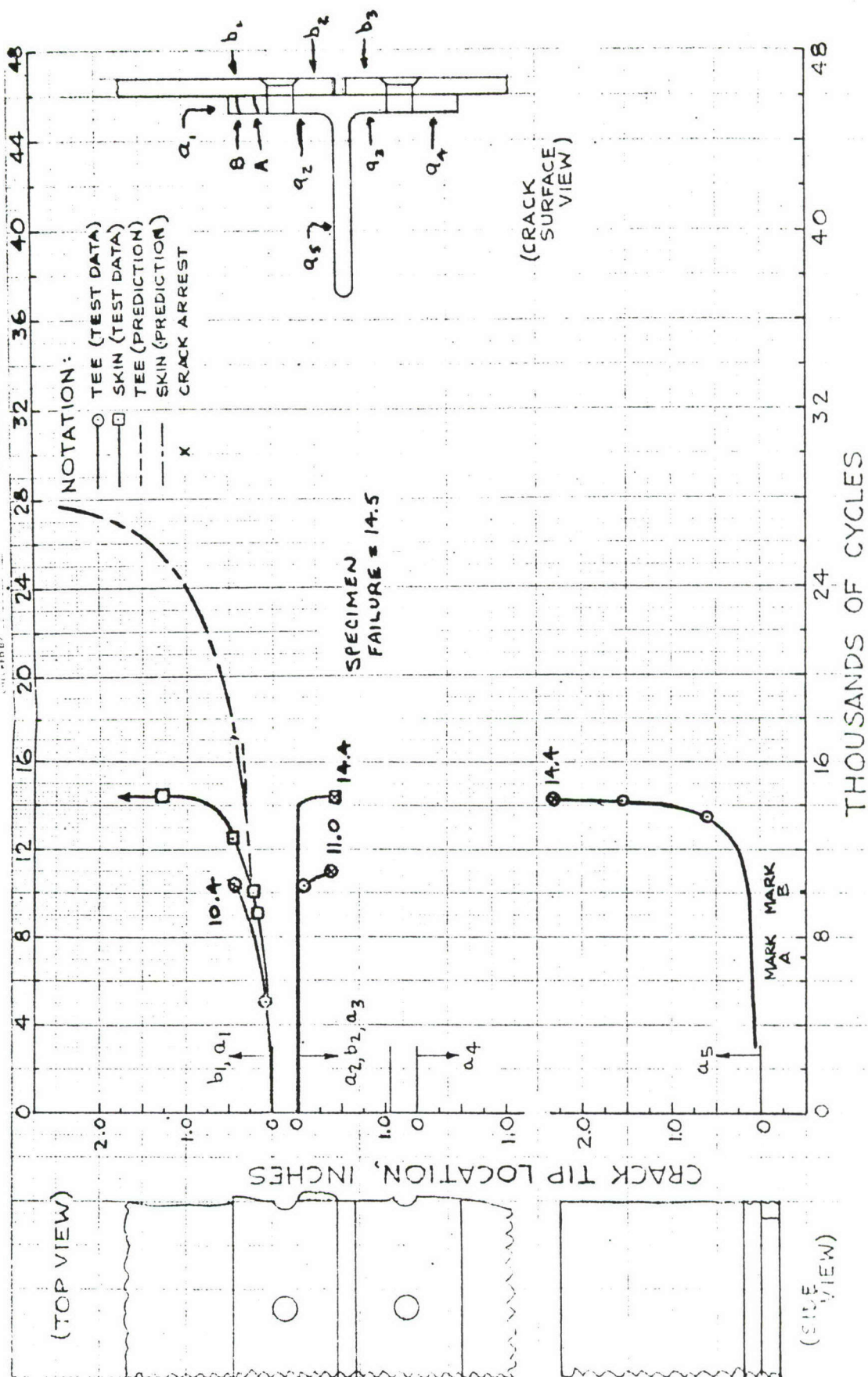


DATA SHEET NO.'s
569712-716

SPECIMEN 4.8-3-8

DATE TESTED:
6/18 TO 6/21/76

N	a ₁	a ₂	a ₃ ⁽⁵⁾	a ₄	a ₅ ⁽⁹⁾	b ₁	b ₂	b ₃	b ₄
0	0.046 ⁽¹⁾				0.09 ⁽²⁾	0.073 ⁽¹⁾			
5.0	DIMPLE								
6.1	0.065					0.076			
7.0	0.112					0.143			
A ⁽¹²⁾ MARK(10)	0.118					0.146			
8.5	0.180					0.221			
10.0	0.237					0.274			
11.5	0.317					0.346			
12.876	0.47 ⁽⁷⁾								
13.0						0.414			
B ⁽¹²⁾ MARK(10)						0.450			
16.0						0.687			
18.0						0.909			
C ⁽¹²⁾ MARK(5)						0.932	0.050 ⁽¹¹⁾		
18.5						1.014	0.108		
18.9						1.154	0.304		
18.97							0.45 ⁽⁷⁾		
19.1						1.378 ⁽¹⁰⁾			
21.9		0.033							
22.0		0.060							
22.1		0.254							
22.13		0.330 ⁽³⁾							
22.27		0.54 ⁽⁴⁾							
22.5			0.78		0.40				
22.54			0.92						
22.55			1.06 ⁽⁶⁾		0.55				
22.6					0.76				
22.7					1.07				
22.85					1.43				
23.0					1.84				
23.01					1.99				
23.014					2.25 ⁽⁷⁾				
23.02				DIMPLE					
23.147				0.112					
23.155				0.47 ⁽⁸⁾					
26.45								0.070	0.065
26.5								0.124	0.167
26.503		F	A	I	L	U	R	E	



DATA SHEET NO's:
569722 TO 725

SPECIMEN 4.8-3-9

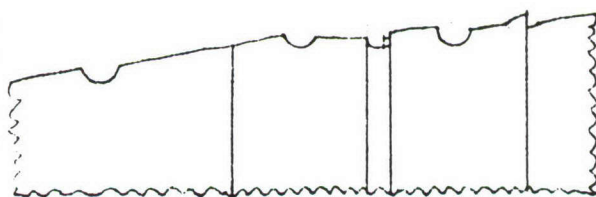
DATES TESTED:
8/11 TO 8/12/76

N	a ₁	a ₂	a ₃	a ₄	a ₅	b ₁	b ₂	b ₄	
0	0.050 ⁽¹⁾	0.020 ⁽¹¹⁾				0.043 ⁽¹⁾		0.020 ⁽¹⁷⁾	
5.0	0.069								
6.0	0.112								
7.0	0.151								
A. MARK(10)	0.153								
8.0	0.204								
9.1	0.260					0.177			
10.0	0.323					0.218			
B. MARK(10)	0.331					0.231			
10.1	0.347	DIMPLE				0.238			
10.2	0.364	DIMPLE				0.242			
10.3	0.394	DIMPLE				0.253			
10.363	0.46 ⁽⁷⁾	0.076				0.255			
10.4		0.093				0.256			
10.5		0.147				0.266			
10.6		0.192				0.283			
10.7		0.253				0.288			
10.8		0.302				0.301			
10.9		0.352 ⁽³⁾				0.312			
11.0		0.370				0.319			
11.5						0.364			
12.0						0.415			
12.5					0.33	0.450			
13.0			DIMPLE		0.38	0.488			
13.5			1.075 ⁽⁶⁾		0.58	0.560			
13.6					0.72	0.598			
13.7					0.88	0.613			
13.8					0.99	0.636			
13.9					1.13	0.665			
14.0					1.26	0.711			
14.1					1.38	0.762			
14.2					1.55	0.816			
14.3					1.69	0.881			
14.375					1.94	0.919			
14.381				DIMPLE	2.25	0.946			
14.449				0.03 ⁽¹⁸⁾		1.275	0.50 ⁽⁷⁾	0.05 ⁽¹⁹⁾	
14.463	F	A	I	L	U	R	E		

SPECIMEN 48-3-10

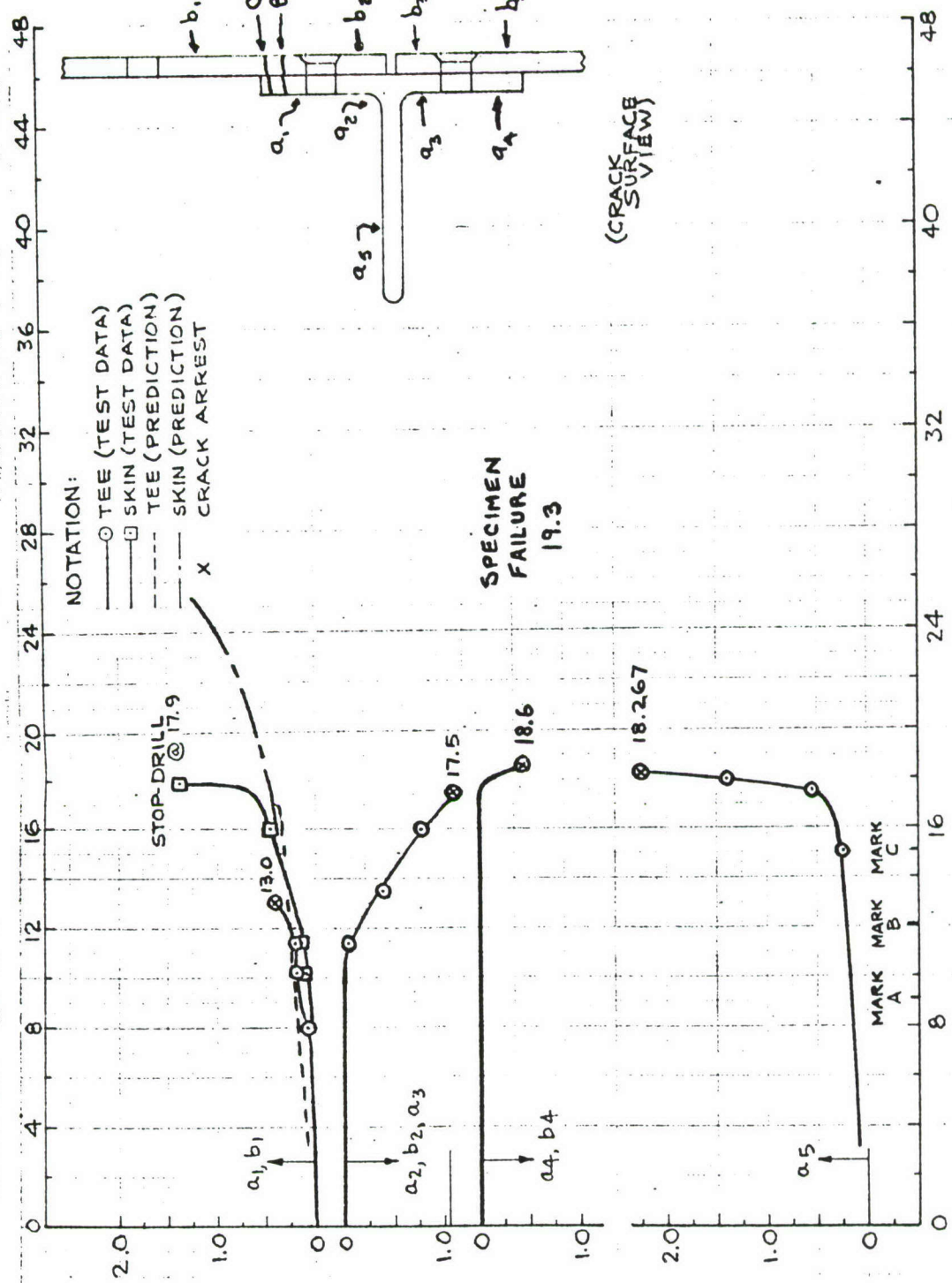
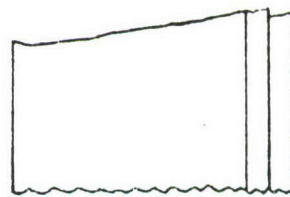
LOCKHEED CALIFORNIA COMPANY

(TOP VIEW)



CRACK TIP LOCATION, INCHES

(SIDE VIEW)



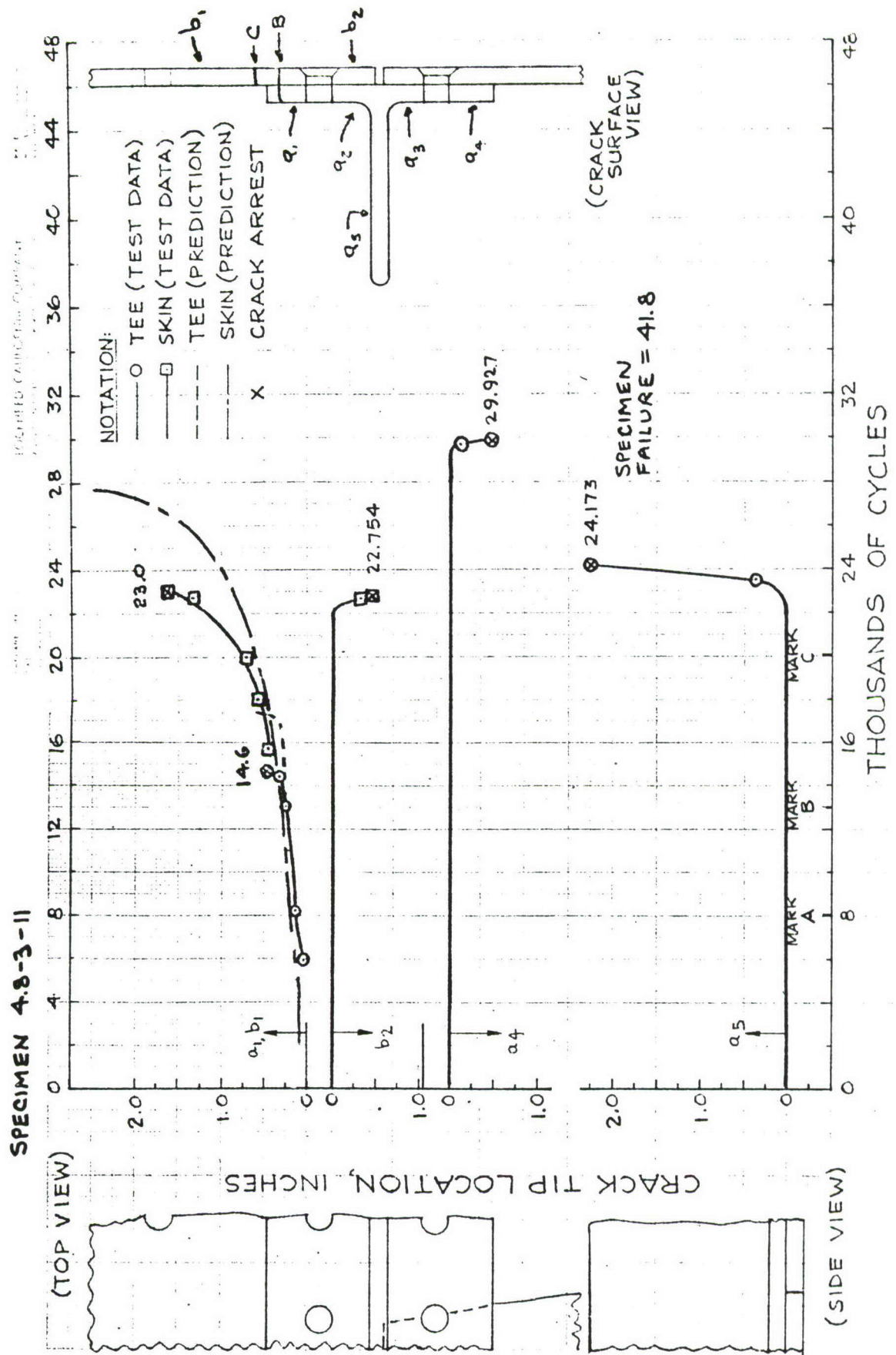
SPECIMEN FAILURE
19.3

(CRACK SURFACE VIEW)

NOTATION:
 ○ TEE (TEST DATA)
 □ SKIN (TEST DATA)
 --- TEE (PREDICTION)
 - - - SKIN (PREDICTION)
 x CRACK ARREST

SPECIMEN 4.8-3-10

N	a ₁	a ₂	a ₃	a ₄	a ₅	b ₁	b ₂	b ₃	b ₄
0	0.055 ⁽¹⁾	0.025 ⁽¹⁷⁾				0.050 ⁽¹⁾			0.027 ⁽¹⁷⁾
6.0	DIMPLE								
6.301	0.030								
7.4	0.040								
8.0	0.070								
9.0	0.146								
A ⁽¹²⁾ MARK (10)	0.154								
10.251	0.182					0.094			
11.402	0.201	0.031				0.147			
12.0	0.248	0.105				0.168			
B ⁽¹²⁾ MARK (10)	0.258	0.115				0.180			
12.5	0.285	0.158				0.205			
13.0	0.41 ⁽⁷⁾	0.230				0.241			
13.5		0.372				0.273			
14.0		③				0.287			
15.0						0.354			
C ⁽¹²⁾ MARK (10)			0.55 ⁽¹¹⁾		0.24 ⁽¹¹⁾	0.366			
15.5					0.29	0.408			
16.0			0.792		0.31	0.458			
16.5			0.906		0.35	0.500			
17.0			0.995		0.41	0.548			
17.5			1.12 ⁽⁶⁾		0.55	0.633			
17.816					0.95	0.900	0.47 ⁽⁷⁾		
17.9					1.13	1.380 ⁽¹⁰⁾			
18.0					1.39				
18.1					1.59				
18.2					1.89				
18.267					2.25 ⁽⁷⁾				
18.6				0.44 ⁽⁸⁾					
18.7									0.147
18.8									0.216
18.9									0.282
19.0									0.370
19.1									0.454
19.2									0.578
19.25									0.714
19.3									0.832
19.318			F	A	I	L	U	R	E



DATA SHEET NO's:

569727-730

SPECIMEN 4.8-3-11

8/13 TO 8/16/1976

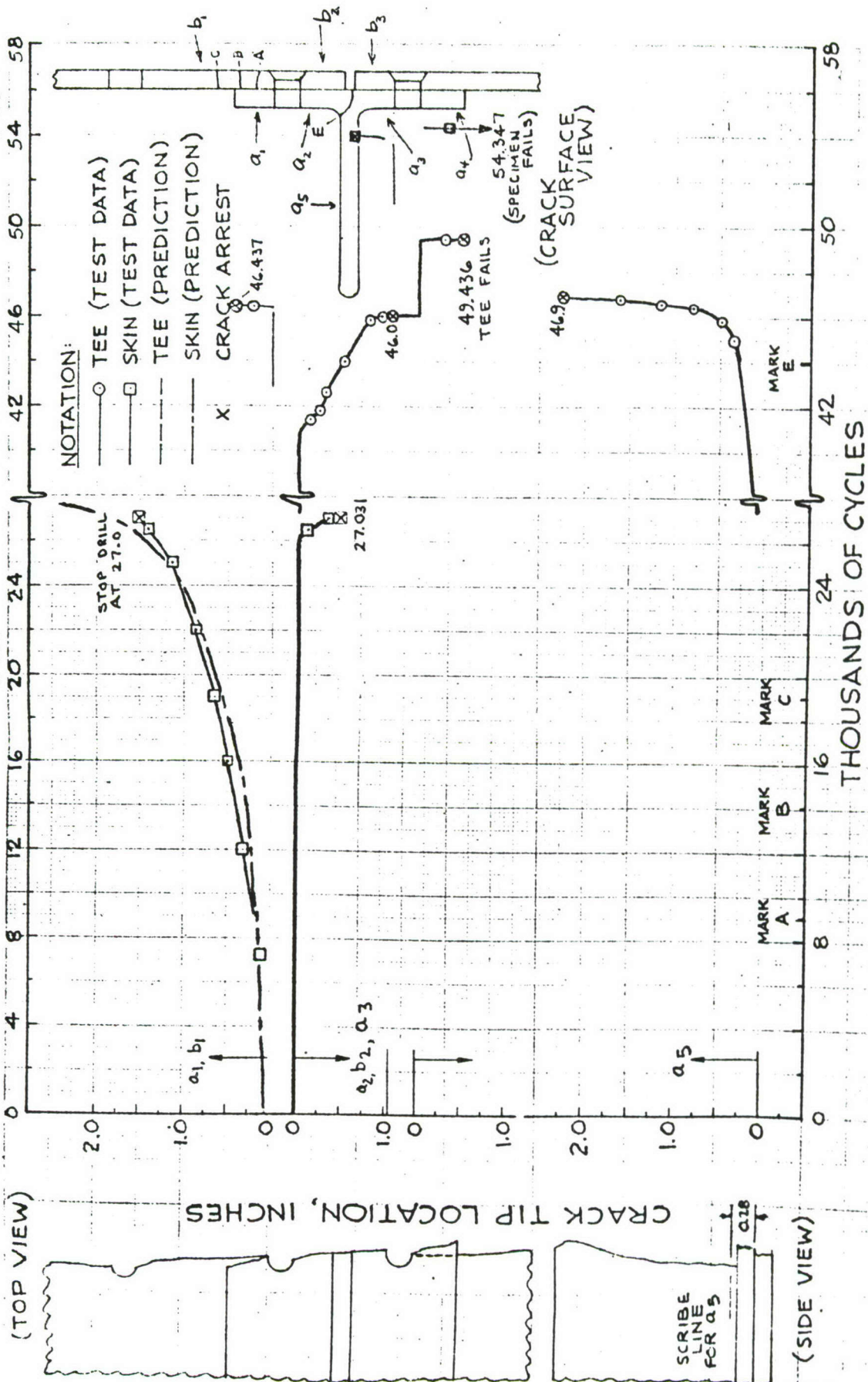
8/13 TO 8/16/1976

N	a ₁	a ₂	a ₃	a ₄ ⁽¹⁵⁾	a ₅	b ₁	b ₂	b ₃ ⁽¹⁵⁾
0	0.056 ⁽¹⁾					0.048 ⁽¹⁾		
6.0	0.028							
7.0	0.092							
8.0	0.119							
A ⁽¹²⁾ MARK (10)	0.126							
8.2	0.129					0.101		
11.0	0.191					0.217		
13.0	0.253					0.308		
B ⁽¹³⁾ MARK (10)	0.264					0.318		
14.353	0.339					0.383		
14.652	0.46 ⁽⁷⁾					0.401		
15.7						0.456		
18.0						0.585		
C ⁽¹²⁾ MARK (10)						0.610		
20.0						0.814		
22.719						1.315	0.317	
22.754						1.375	0.46 ⁽⁷⁾	
23.0						1.615 ⁽¹⁰⁾		
23.5		③			0.37			
23.7			⑥		0.81			
23.8					1.13			
23.9					1.39			
24.0					1.64			
24.1					1.87			
24.173					2.25 ⁽⁷⁾			
29.7				0.13				
29.8				0.17				
29.9				0.26				
29.927				0.48 ⁽⁸⁾				
41.5								0.26
41.564								0.47 ⁽⁷⁾
41.757		F	A	I	L	U	R	E

SPECIMEN 4.8-3-12

LOCKHEED CALIFORNIA COMPANY

PHOTOGRAPHY



DATA SHEET NO.'s:

569732 - 736

SPECIMEN 4.8-3-12

DATES TESTED:

8/17 TO 8/19/76

N	a ₁	a ₂	a ₃	a ₄	a ₅	b ₁	b ₂	b ₃	
0						0.052 ⁽¹⁾			
7.2						0.093			
8.0						0.135			
9.0						0.183			
A MARK (10)						0.190			
10.0						0.225			
12.0						0.311			
14.0						0.401			
B. MARK (10)						0.403			
16.0						0.499			
19.0						0.650			
C. MARK (10)						0.669			
22.0						0.862			
25.0						1.132			
26.5						1.405	0.105		
27.0						1.512 ⁽¹⁰⁾	0.339		
27.031							0.48 ⁽⁷⁾		
29.0									
D. MARK (10)									
41.0		DIMPLE							
41.4		0.133							
41.8		0.219							
42.2		0.302							
42.6		0.358 ⁽³⁾							
44.0									
E. MARK (10)			0.52						
45.0					0.36				
45.5			DIMPLE		0.39				
45.85			0.797		0.49				
46.0			0.914 ⁽¹⁶⁾		0.55				
46.4	DIMPLE				0.81				
46.432	0.223				0.84				
46.437	0.50 ⁽⁷⁾								
46.55					1.16				
46.75					1.62				
46.9					2.25 ⁽⁷⁾				
49.432				0.29					
49.436				0.48 ⁽⁸⁾					
54.0								0.48	
54.347		F	A	I	L	U	R	E	



DATA SHEET NO's.: SPECIMEN 4.8-3-13
569737-740

DATE TESTED:
9/1/1976

N	a ₁	a ₂	a ₃ ⁽⁵⁾	a ₄ ⁽¹⁷⁾	a ₅ ⁽⁹⁾	b ₁ ⁽¹⁷⁾	b ₂	DEPTH OF b ₂	b ₄ ⁽¹⁷⁾
0		0.045 ⁽¹⁾		0.025 ⁽¹⁷⁾	0.09 ⁽²⁾	0.021 ⁽¹⁷⁾	0.037 ⁽¹⁾	0.04 ⁽²⁾	0.021 ⁽¹⁷⁾
5.5		0.039							
6.0		0.079							
7.0		0.144							
A ⁽¹²⁾ MARK (10)									
8.5		0.219					0.142		
10.0		0.290					0.232		
11.0		0.331					0.307		
12.0		0.375 ⁽³⁾					0.381		
12.5		0.383	0.41 ⁽¹⁹⁾				0.48 ⁽⁷⁾		
B ⁽¹⁹⁾ MARK (10)			0.42 ⁽¹⁹⁾						
14.5			0.545 ⁽⁴⁾						
15.0			0.575 ⁽⁴⁾						
15.1									
15.246						0.233			
16.1						0.469			
17.1						0.947			
17.2					0.37	1.015			
17.4					0.41	1.157			
17.5			0.765		0.43	1.237			
17.6			0.826		0.47	1.331			
17.7	0.031		0.906		0.51	1.434			
17.735	0.105		1.078						
17.744	0.106		1.080 ⁽⁶⁾						
17.8	0.193				0.65	1.602 ⁽¹⁰⁾			
17.85	0.48 ⁽⁷⁾				1.13				
17.875					1.56				
17.9					1.91				
17.925					2.25 ⁽⁷⁾				
19.325									0.120
19.375									0.150
19.425									0.197
19.475									0.240
19.525									0.294
19.575				0.16 ⁽¹⁸⁾					0.380
19.583		F	A	I	L	U	R	E	

LOCKHEED-CALVERT COMPANY
A Division of Lockheed Martin Corporation



SPECIMEN 4.8-3-14

N	a ₁	a ₂	a ₃	a ₄	a ₅	b ₁	b ₂	b ₃	b ₄
0		0.051 ⁽¹⁾		0.022 ⁽¹⁷⁾	0.07 ⁽²⁾	0.021 ⁽¹⁷⁾	0.043 ⁽¹⁾		0.022 ⁽¹⁷⁾
6.0		0.048							
7.0		0.082							
8.0		0.132							
A ⁽¹²⁾ MARK (10)		0.138							
9.152		0.185					0.111		
11.0		0.247					0.185		
13.0		0.315					0.256		
14.5		0.353 ⁽³⁾					0.315		
15.5							0.386		
16.0							0.447		
16.133							0.51 ⁽⁷⁾		
B ⁽¹²⁾ MARK (10)			0.51 ⁽¹⁹⁾			0.185			
17.133						0.386			
18.133						0.697			
19.133						0.932			
19.633					0.35	1.170			
20.133					0.41	1.525 ⁽¹⁰⁾			
20.5			1.01		0.56	2.00 ⁽²⁰⁾			
20.55			1.04 ⁽⁶⁾		0.81	↑			
20.6				0.017	1.01				
20.65				0.273	1.31				
20.7				0.50 ⁽¹⁾	1.61				
20.75					1.96				
20.775	(21)				2.25 ⁽⁸⁾				
21.575									0.181
21.675									0.260
21.775									0.350
21.875									0.480
21.925						2.00 ⁽²⁰⁾			0.620
21.949		F	A	I	L	U	R	E	

SECTION VII

EDGE STRINGER SPECIMENS

The following pages present crack growth data and predictions for 12 edge stringer specimens. Specimen configurations and their initial damage conditions are shown in Figure B-2 (Appendix B) and Table 3 of Volume I.

For each specimen there is a plot showing the entire crack growth history and comparing it to the prediction. In addition, a one-page table gives the crack length versus cycles test data along with explanatory notes and sketches.

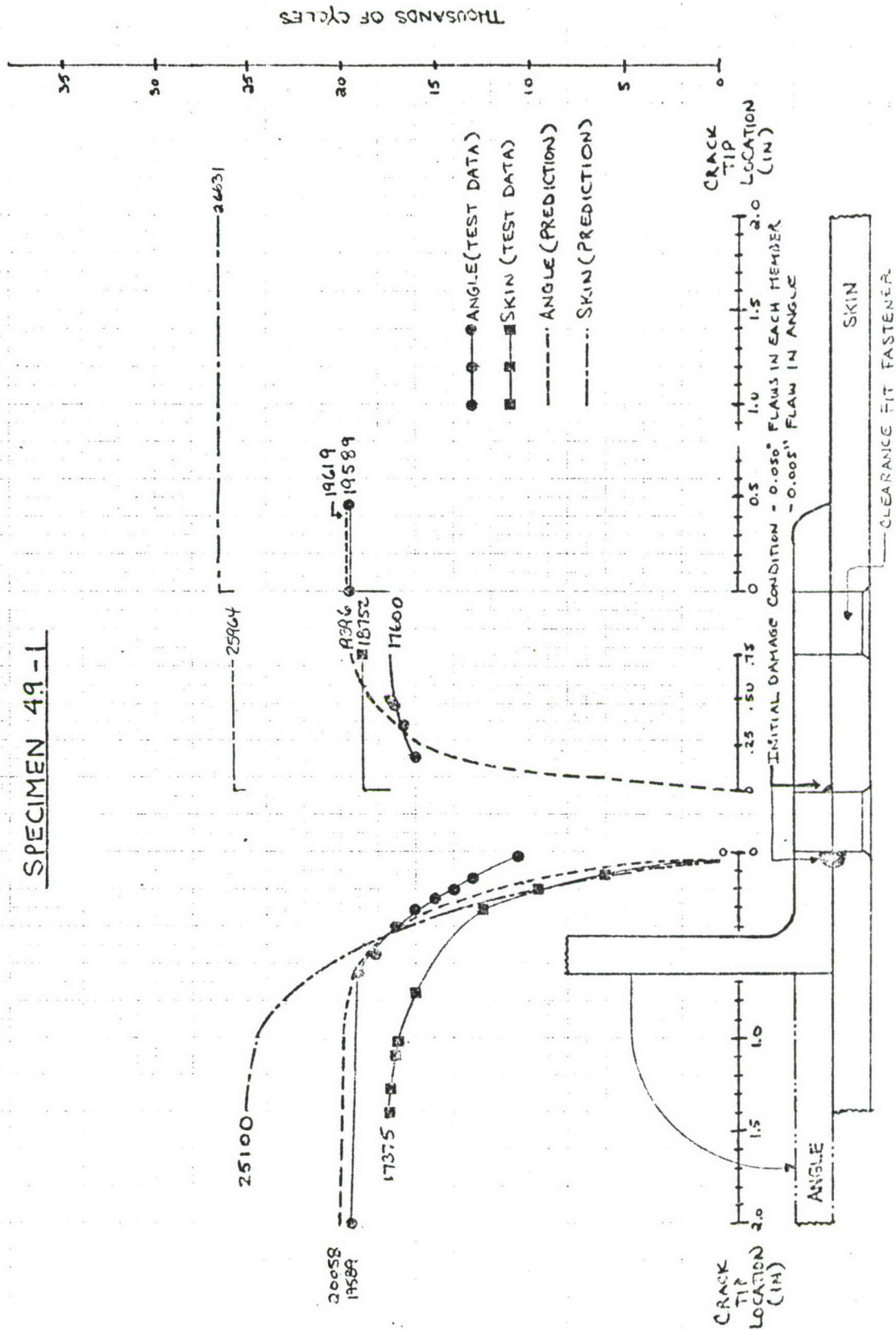
All crack lengths are as measured from the edge of a hole, not from the edge of a countersink or collar.

As previously, a stop-drill hole was often put in the skin about 1.6 inches* inside the innermost fastener to prevent unstable growth of the skin crack and allow time for further stable growth elsewhere in the specimen. A (nominally) 0.375-inch diameter hole was used, and a clearance-fit fully-torqued Hi-lok fastener was placed in the hole to prolong the arrestment of the crack.

For specimens with initial outside cracks the stop drilled hole was usually drilled after arrestment but before reinitiation of the skin crack in the innermost fastener.

*Dimension given is from the edge of the fastener hole to the edge of the stop-drill hole.

SPECIMEN 49-1

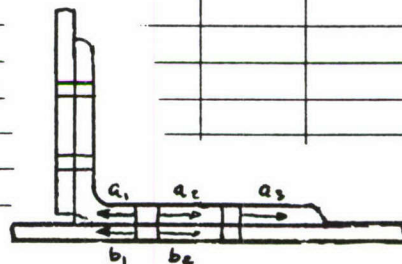


DATE SHEET NO. S: 573637-38

TEST DATE(S): 1/27/77 - 1/28/77

SPECIMEN 4.9-1

N	a_1	a_2	a_3	b_1	b_2				
0	.029*	.023*		.06*					
6000	—	—		.17					
7500	—	—		.21					
9000	—	—		.24					
9500	—	—		.27					
10200	—	—		.33					
10600	.02	—		.38					
11200	.04	—		.43					
12400	.12	—		.48					
13000	.14	—		.52					
14000	.20	—		.62					
15000	.25	—		.70					
16000	.31	.22		.83					
16200	.32	.27		.89					
16600	.36	.33		.98					
16900	.38	.42		1.09					
17100	.40	.46		1.17					
17300	.46	.50		1.34					
17375	.46	.50		TO EDGE					
17600	.50	TO NEXT FASTENER							
18100	.55								
18600	.60								
18752	—					TO NEXT FASTENER			
19052	.65								
19340	.85								
19350	1.05								
19355	1.20								
19366	1.57								
19382	1.94								
19480	2.16								
19510	—		DIMPLE						
19520	2.20		.18						
19525	2.26		.26						
19526	—		TO EDGE						
19565	2.35								
19585	2.40								
19589		F	A	I	L	U	R	E	

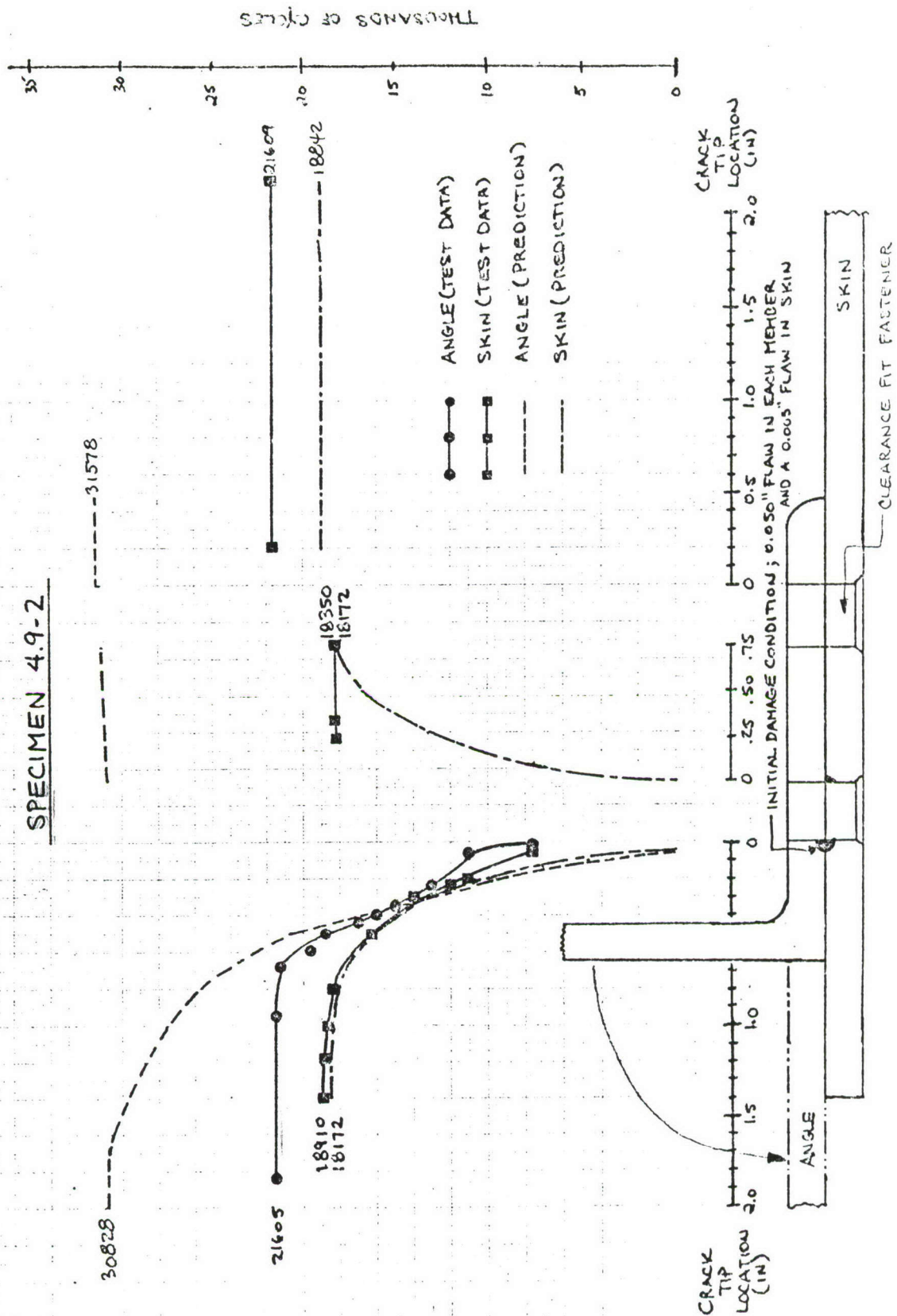


DATA IDENTIFICATION

NOTES

* INITIAL MEASUREMENTS
ARE FOR CORNER FAN.
SUBSEQUENT MEASUREMENTS
ARE FOR THE CRACK LENGTH
AT THE SURFACE
* CRACK GREW TO ARRESTMENT
UN-NOTICED.

SPECIMEN 4.9-2

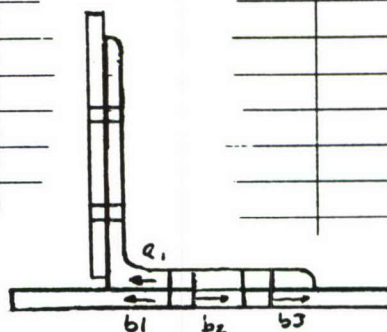


DATA SHEET NO.S: 573641-42

TEST DATE(S): 1/31/77 - 2/1/77

SPECIMEN 4.9-2

N		a_1	b_1	b_2	b_3				
0		.041*	.050*	.021*					
7600		.01	.12	—					
7900		.01	.18	—					
9500		.05	.23	—					
11000		.06	.27	—					
12000		.22	.30	—					
14000		.34	.37	—					
15000		.35	.49	—					
16000		.40	.56	—					
17000		.44	.64	—					
18200		.47	.71	.31					
18250		.47	.75	.35					
18300		.47	.75	.41					
18350		.48	.75	TO NEXT FASTENER					
18400		.48	.87						
18500		.48	.96						
18650		.48	1.07						
18800		.50	1.16						
18850		.50	1.25						
18900		.52	1.32						
18910		.52	TO EDGE						
19620		.60							
20620		.68							
21420		.95							
21431		1.08							
21443		1.30							
21453		1.40							
21473		1.50							
21533		1.70							
21573		1.78							
21605		1.84			.31				
21609	F	A	I	L	U	R	E		

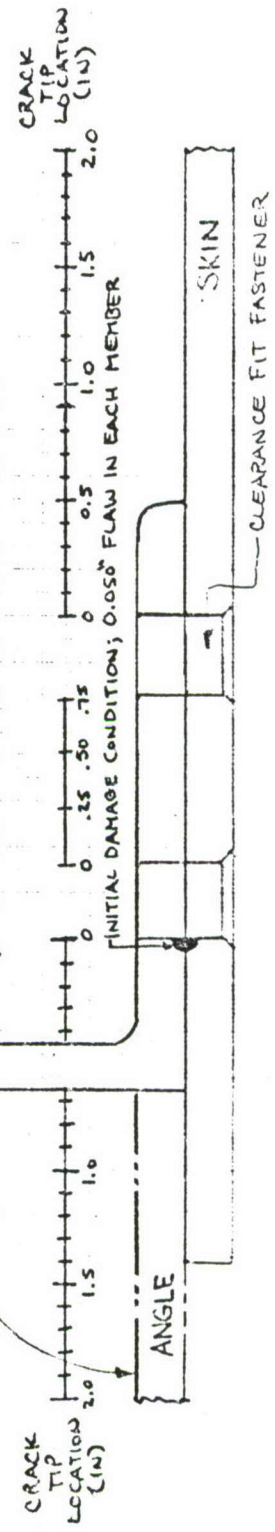
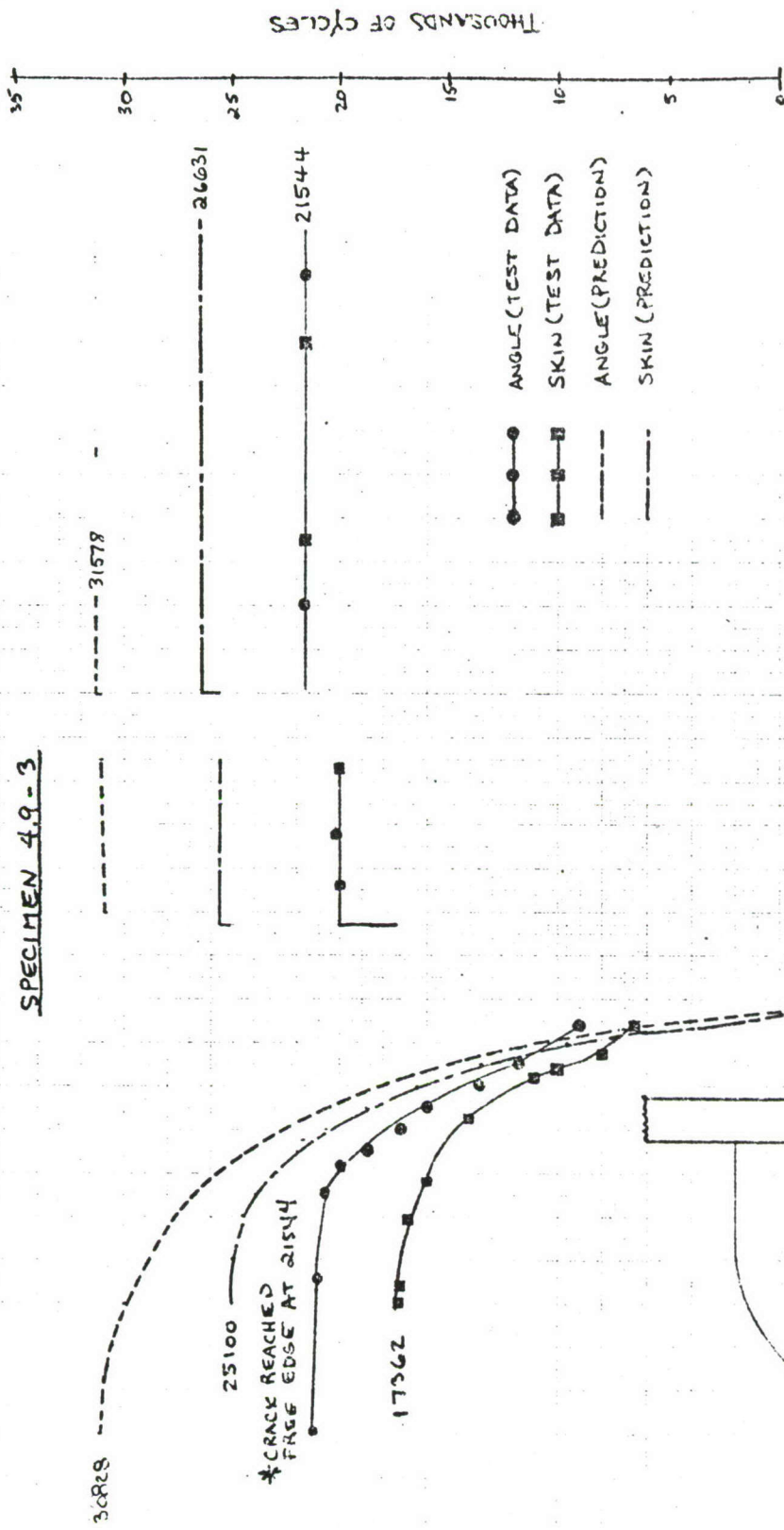


DATA IDENTIFICATION

NOTES

* THESE MEASUREMENTS ARE FOR THE INITIAL CORNER FLAW. SUBSEQUENT MEASUREMENTS ARE FOR THE CRACK LENGTHS AT THE SURFACE

SPECIMEN 4.9-3



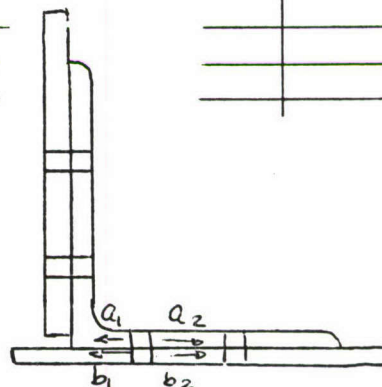
DATE SHEET NO. S: 573639-40

SPECIMEN 4.9-3

TEST DATE(S): 1/28/77

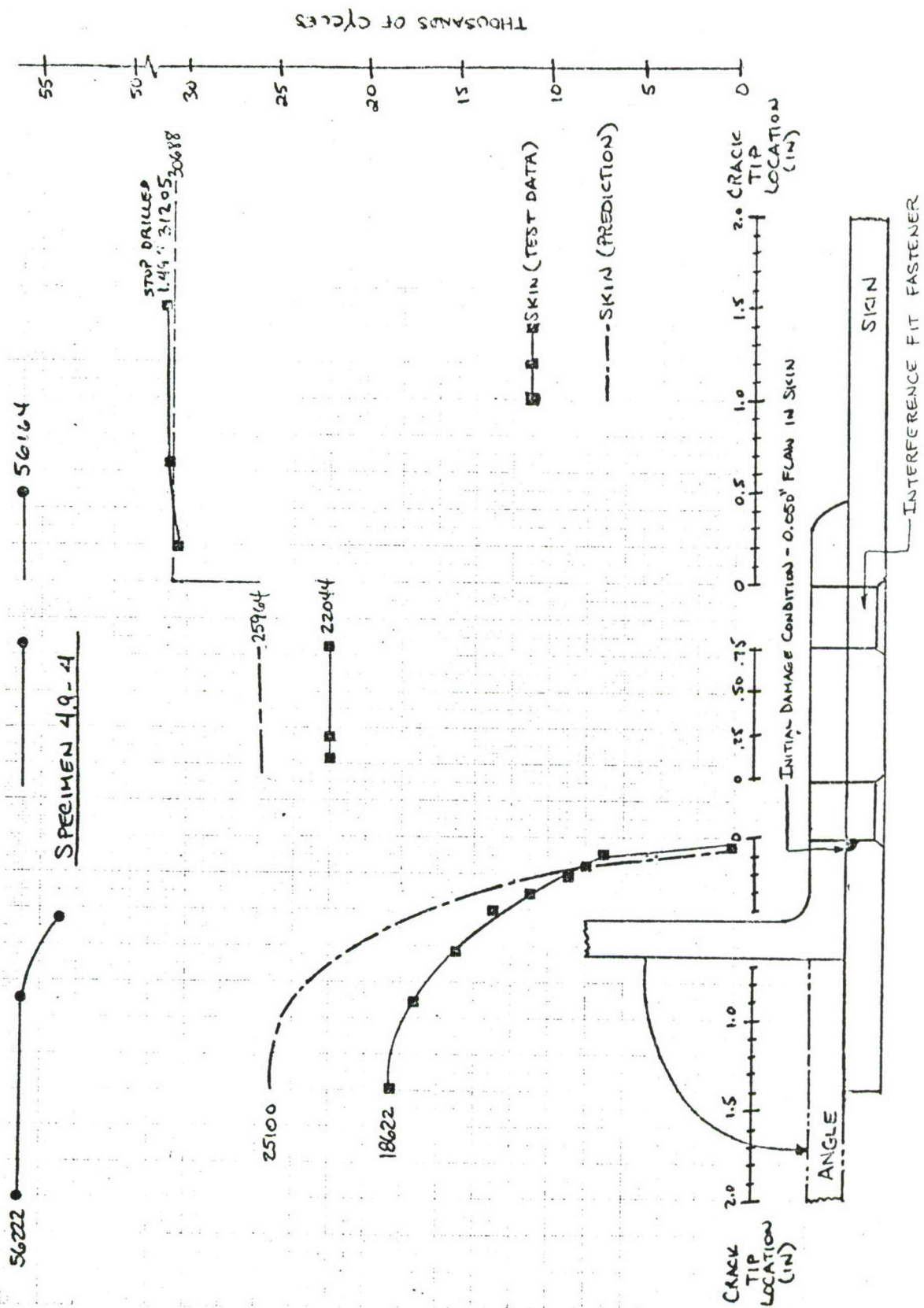
- 1/31/77

N	Q_1	Q_2	b_1	b_2				
0	.053*		.065*					
6540	—		.12					
7540	—		.22					
9068	.04		.27					
10068	.11		.32					
11200	.17		.43					
12800	.23		.54					
13600	.30		.57					
14400	.32		.68					
15200	.37		.80					
16000	.40		.91					
16400	.43		.99					
16800	.45		1.08					
17200	.50		1.39					
17362	.50		TO EDGE					
18162	.55							
18762	.60							
20022	.68							
20042	.68			.38				
20044	.68			TO NEXT FASTENER				
20962	.80							
20994	.98							
21012	1.20							
21052	1.30							
21138	1.57							
21157	1.68	TO NEXT FASTENER						
21187	1.85							
21237	2.00							
21457	2.26							
21537	2.30							
21544	F	A	I	L	U	R	E	



DATA IDENTIFICATION

NOTE * THESE MEASUREMENT ARE THE MANUFACTURED
INITIAL CORNER FLAW. SUBSEQUENT MEASUREMENTS
ARE FOR THE CRACK LENGTH AS VIEWED AT
THE SURFACE

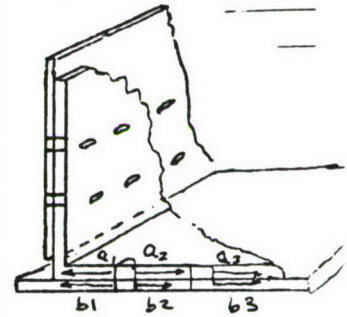


DATA SHEET NO. 8: 573646-48

TEST DATA(S): 2/15/77 - 2/17/77

SPECIMEN 4.9-4

N	a ₁	a ₂	a ₃	b ₁	b ₂	b ₃	b _{3F}		
0				.056*					
7010				.10					
8000				.17					
9000				.21					
11000				.32					
13000				.41					
15000				.64					
17200				.92					
17900				1.02					
18200				1.11					
18500				1.27					
18600				1.38					
18622				TO EDGE					
21984					.11				
22014					.20				
22034					.26				
22044					TO NEXT FASTENER				
30544						.19			
30785						.27			
30915						.45			
30965						.55			
31015						.65			
31085						.85	.77		
31145						1.05	1.00		
31185						1.25	1.23		
31205							1	1	
53905	.46								
55989	.90	TO NEXT FASTENER							
56164			TO EDGE						
56222	F	A	I	L	U	R	E		

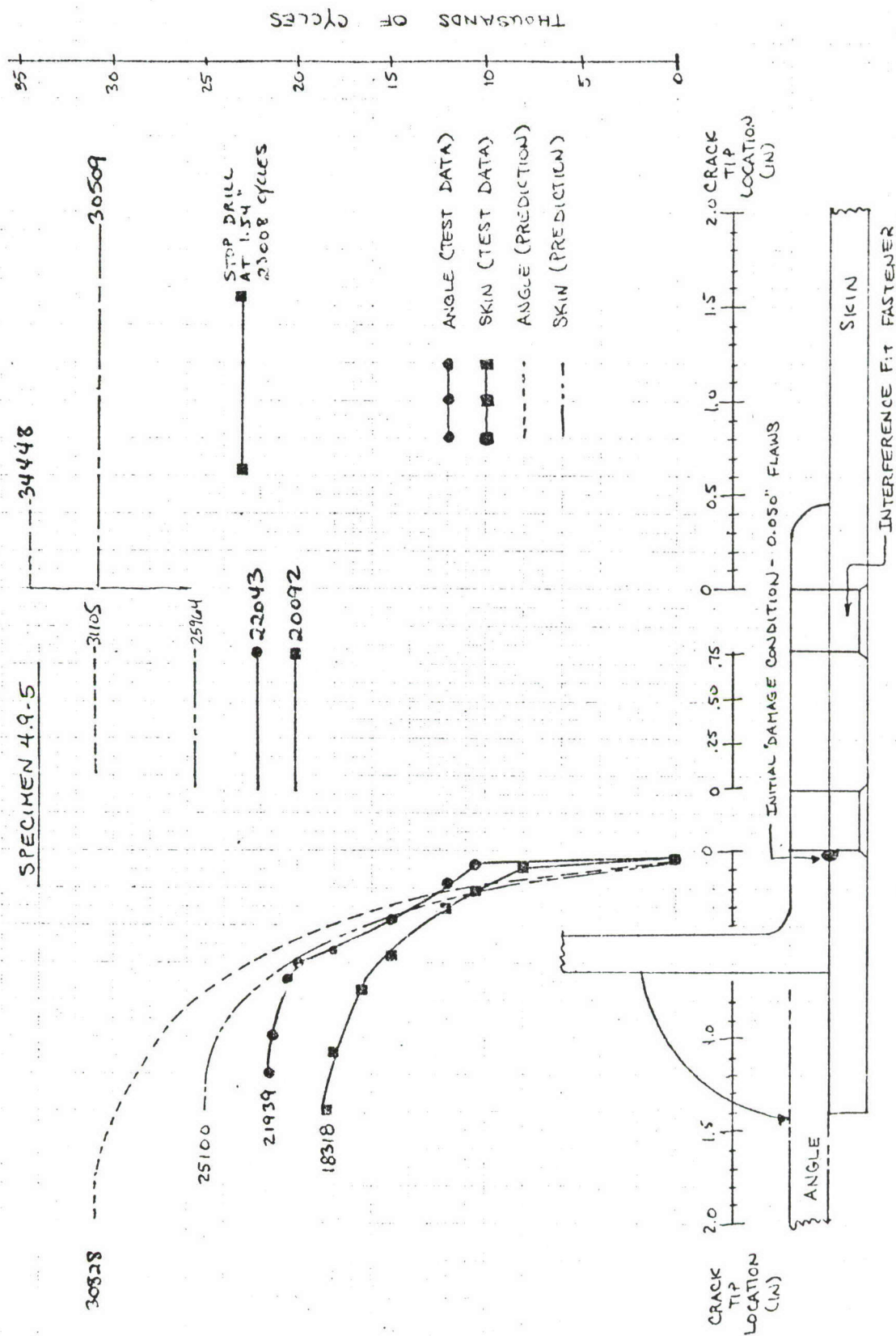


DATA IDENTIFICATION

NOTE: * THESE MEASUREMENTS ARE FOR THE MANUFACTURED INITIAL CORNER FLAW. SUBSEQUENT MEASUREMENTS ARE FOR CRACK LENGTH VIEWED AT SURFACE

¹ BROKE THRU TO STOP DRILLING AT A LENGTH OF 1.49 IN

² CRACK b_{3F} IS SAME AS CRACK b₃, BUT VIEWED FROM FRONT OF SPECIMEN.

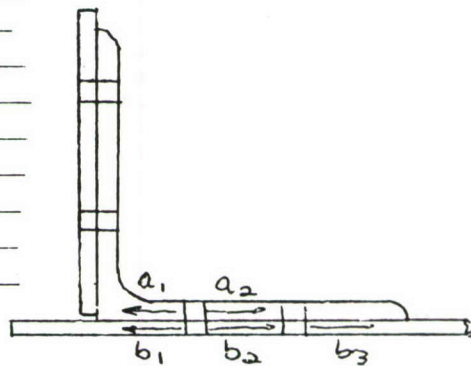


DATA SHEET NO. 5: 573302-3

TEST DATE(S): 2/18/77

SPECIMEN 4.9-5

N	a ₁	a ₂	b ₁	b ₂	b ₃				
0	.050*		.051*						
8000	—		.10						
10500	.08		.21						
12000	.18		.32						
13500	.27		.45						
15000	.38		.57						
16500	.48		.75						
18000	.53		1.08						
18318	—		TO EDGE						
20000	.60								
20092	—			TO NEXT FASTENER					
20592	.70								
21304	1.00								
21357	1.18								
21457	1.20								
21757	1.22								
21939	1.24 ¹								
22043		TO NEXT FASTENER							
23003									
23008					.63 ²				
23143 ³					1.54 ²				
23420	F	A.	I	L	U	R	E		



DATA IDENTIFICATION

NOTES: * THESE MEASUREMENTS ARE FOR THE MANUFACTURED INITIAL CORNER FLAW. SUBSEQUENT MEASUREMENTS ARE FOR CRACK LENGTHS VIEWED AT THE SURFACE

¹ CRACK WENT UP THE OUTSTANDING LEG AND ARRESTED AT THE FIRST FASTENER JOINING WEB TO ANGLE

² CRACK BROKE THRU TO STOP DRILL AT 1.54 IN.

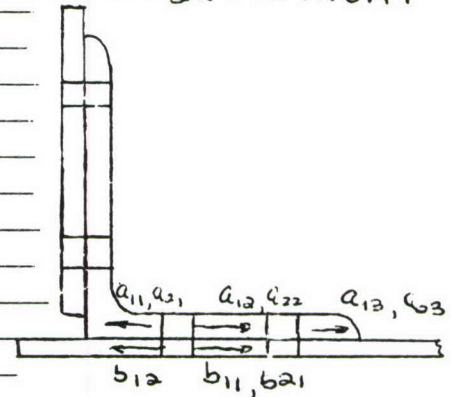
³ CRACK WENT FROM FIRST FASTENER IN OUTSTANDING LEG TO SECOND FASTENER IN LEG

DATA SHEET NO. S: 573306-9

TEST DATE(S): 2/24/77 - 3/1/77

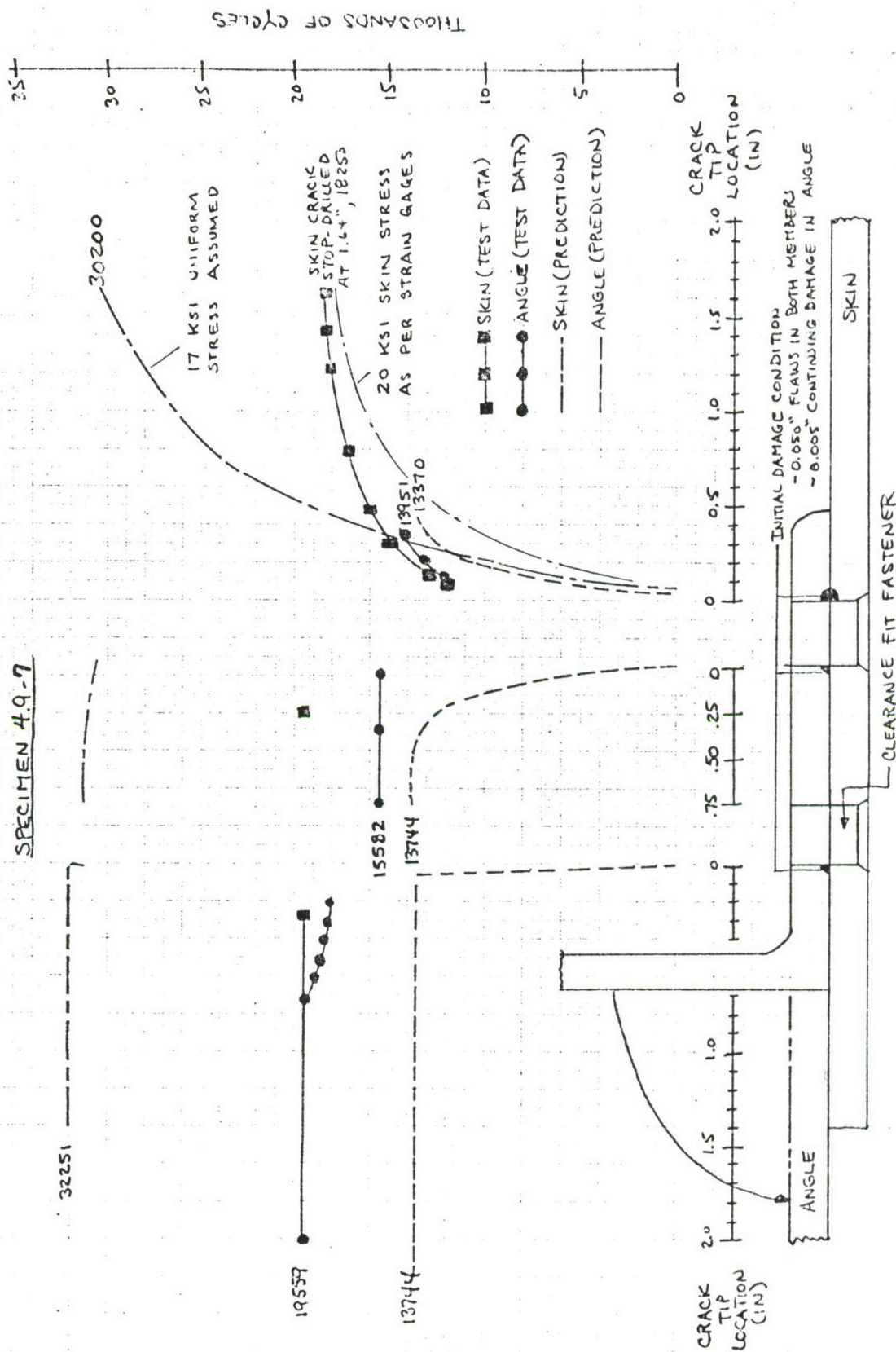
SPECIMEN 4.9-6

N	a ₁₁	a ₁₂	a ₁₃	a ₂₁	a ₂₂	a ₂₃	b ₁₁	b ₁₂	b ₂₁
0	.058*			.082*					
8000	.05			—					
8459	.06			.06					
8959	.16	.12		.12					
9860	.24	.30		.13					
10380	—	TO NEXT FASTENER		—					
11360	.43			.26					
15360	.66			.46	.10				
15860	.70			.50	.22				
17171	.78			.55	TO NEXT FASTENER				
17671	1.00			.64					
17971	1.36			.68					
18472	1.60			.70					
18872	1.83			.70					
18972	1			.70					
19972				1.00					
20672				1.34					
21072				1.59					
21472				1.87					
21572				1					
21852			.13						
22100			.22						
22239			TO EDGE						
30039						.14			
31190						.32			
31495						TO EDGE			
32872	TEST DELAY DUE TO STUD FAILURE IN GRIPS								
36500						.07			
26900	NOTES: *THESE MEASUREMENTS ARE FOR THE MANUFACTURED INITIAL CORNER FLAW. SUBSEQUENT MEASUREMENTS ARE FOR CRACK LENGTHS VIEWED AT THE SURFACE.					.17			
37600						.27			
37900						.42			
37910						TO NEXT FASTENER			
38000	CRACK ARRESTED AT OUTERMOST FASTENER IN OUTSTANDING LEG OF						.13	.10	
38100	ANGLE						.34	.14	
38225							.78	.19	
38246							TO EDGE	.20	
38642	F	A	I	L	U	R	E		



DATA IDENTIFICATION

SPECIMEN 4.9-7



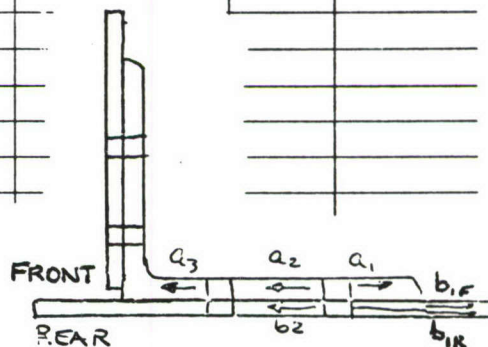
DATA SHEET NO. S-573631-33

TEST DATE(S): 1/20/77

SPECIMEN 4.9-7

-1/24/77

N	a_1/b_{1F} **	a_2	a_3	b_{1R}	b_2				
0	.048*	.017*	.022*	.052*					
10900	.06	—	—	.16					
11500	.09	—	—	.20					
12000	.12	—	—	.21					
13000	.14	—	—	.29					
13500	.28	—	—	.31					
13951	TO EDGE	—	—	.32					
15500**	.46	.34	—	.45					
15582	—	TO NEXT FASTENER	—	—					
16000	.50		—	.48					
16500	.64		—	.60					
17000	.76		—	.80					
17300	.86		—	.86					
17500	.98		—	1.02					
17700	1.16		—	1.13					
18000	1.28		—	1.24					
18200	1.44		—	1.42					
18250	1.56 ¹		.24	1.64 ¹					
18300			.35						
18400			.42						
18500			.50						
18600			.53						
18700			.59						
19150			.60						
19550			.72		.27				
19559	F	A	F	L	U	R	E		

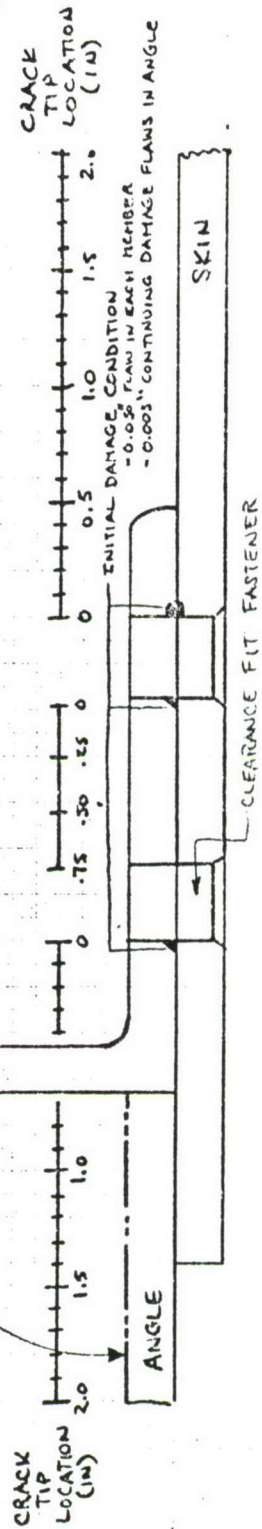


DATA IDENTIFICATION

NOTES: * THESE MEASUREMENTS ARE FOR THE MANUFACTURED INITIAL CORNER FLAW. SUBSEQUENT MEASUREMENTS ARE FOR CRACK LENGTHS VIEWED AT THE SURFACE

** THE NOTATION " b_{1F} " REFERS TO THE SKIN CRACK AS VIEWED FROM THE FRONT SIDE OF THE PANEL

1 THE SKIN CRACK BROKE THRU TO THE STOP DRILLING AT 1.66 IN.



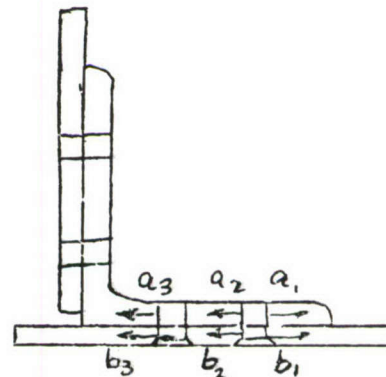
DATA SHEET NO.3: 573643-5

TEST DATE(S) .2/1/77

-2/3/77

SPECIMEN 4.9-8

N	a ₁	a ₂	a ₃	b ₁	b ₂	b ₃			
0	.051*	.016*	.013*	.05*					
7600	.08	—	—	.15					
9100	.16	—	—	.25					
10600	.25	—	—	.28					
12600	.32	—	—	.41					
12800	.40	—	—	.42					
12922	TO EDGE	—	—	.42					
13800		—	—	.51					
14800		—	—	.71					
16722		"DIMPLE"	—	.94					
17048		TO NEXT FASTENER	—	1.05					
17300			—	1.24 ¹					
18200			—		"DIMPLE"				
18262			—		.18				
18272			—		TO NEXT FASTENER				
20800			"DIMPLE"						
20980			.11						
21260			.50						
21560			.58			.18			
21590			.58			.42			
21610			.58			.63			
21618			.62			TO EDGE			
21655			.80						
21665			.90						
21674			1.21						
21680			1.51						
21685			1.70 ²						
22076	F	A	I	L	U	R	E		



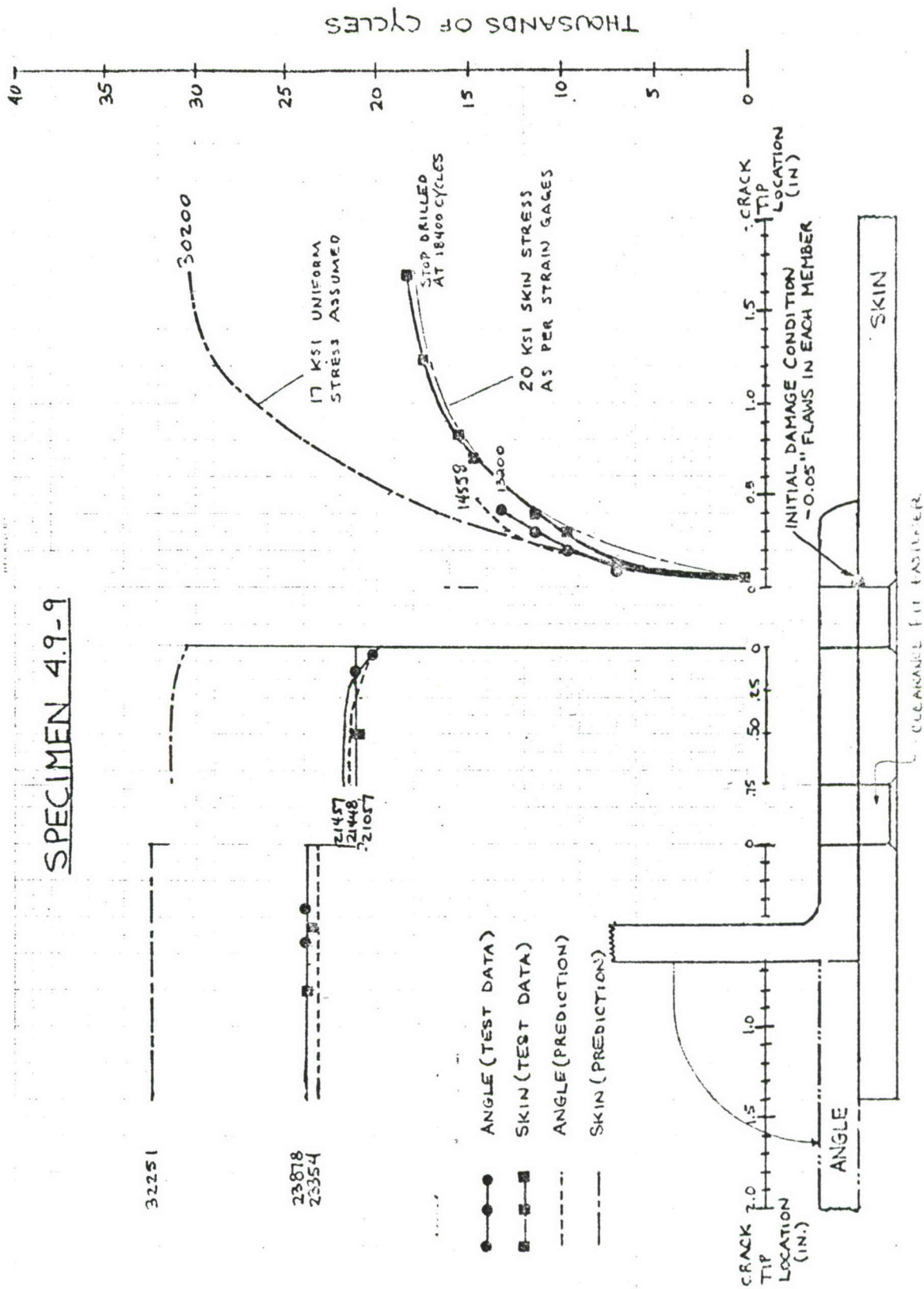
DATA IDENTIFICATION

NOTES: * THESE MEASUREMENTS ARE FOR THE MANUFACTURED INITIAL CORNER FLAWS, SUBSEQUENT MEASUREMENTS ARE FOR CRACK LENGTHS AS VIEWED FROM THE SURFACE

¹ THE CRACK TIP WAS STOP DRILLED

² THE CRACK GREW UP THE OUTSTANDING LEG AND ARRESTED AT THE FIRST FASTENER JOINING THE LEG TO THE WEB

SPECIMEN 4.9-9

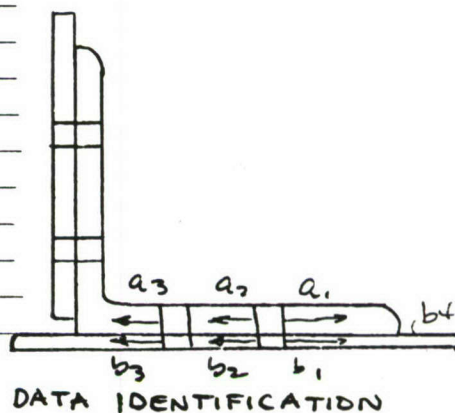


DATA SHEET NO. S: 573634-36

TEST DATE(S): 1/26/77 - 1/27/77

SPECIMEN 4.9-9

N	a_1/b_4^{**}	a_2	a_3	b_1	b_2	b_3			
0	.070*			.073*					
7000	.070			.10					
7800	.14			.19					
9600	.20			.30					
11400	.30			.40					
13200	.42 ²			.54					
14600	.70**			.70					
15600	.83			.84					
16200	.94			.94					
16800	1.07			1.07					
17400	1.22			1.24					
18000	1.45			1.45					
18400	1.70 ¹			1.70 ¹					
20400		.04							
20900		.08							
21057		.10							
21257		.15							
21457		TO NEXT FASTENER							
23721						.46			
23771						.80			
23793									
23858			.35						
23865			.52						
23878	F	A	I	L	U	R	E		



NOTES: * THESE MEASUREMENTS REFER TO THE MANUFACTURED INITIAL CORNER FLAWS. SUBSEQUENT MEASUREMENTS ARE FOR CRACK LENGTHS AS VIEWED FROM THE SURFACE.

** ONCE THE CRACK HAD REACHED PAST THE ANGLE, CRACK MEASUREMENTS WERE TAKEN FROM THE FRONT AND THE BACK OF THE PANEL

¹ THE CRACK TIP WAS STOP DRILLED AT 1.66 IN

² ANGLE CRACK a_1 ARRESTED AT EDGE AT 13,200 CYCLES.

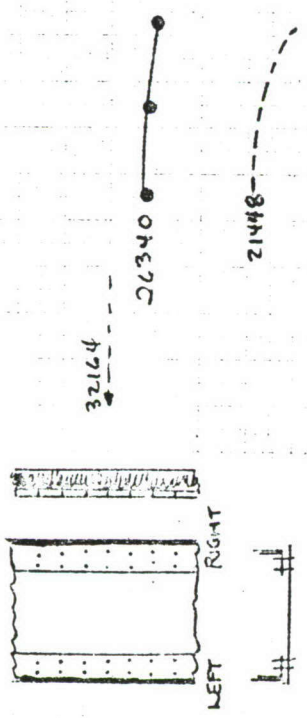
45924

CHECKED BY

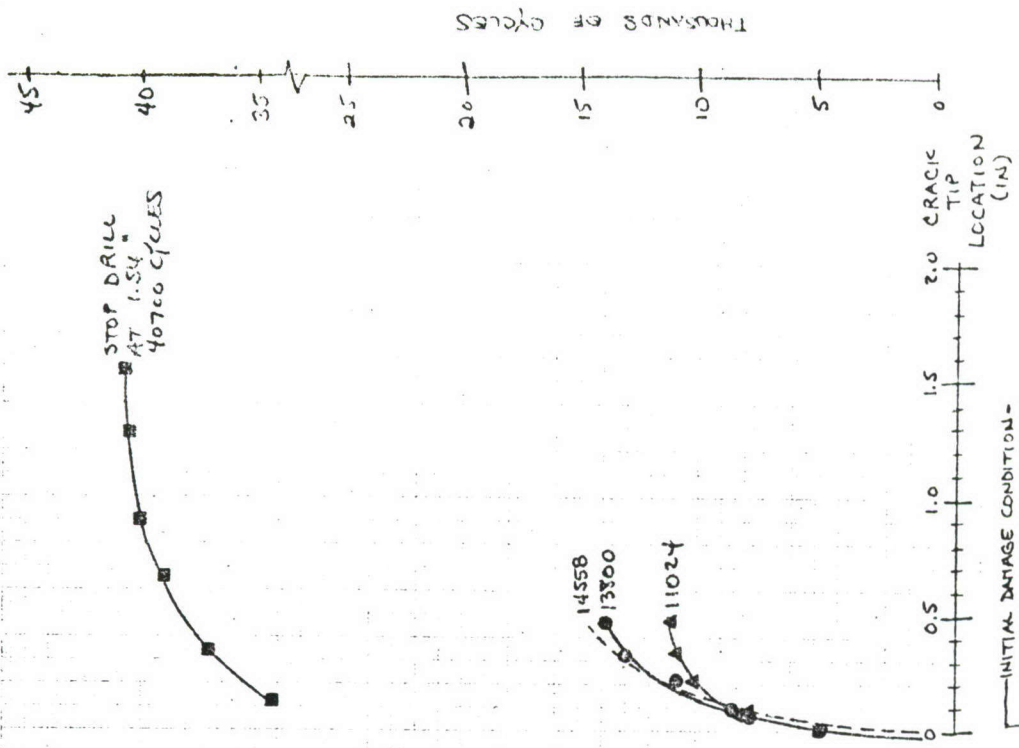
45110

SPECIMEN 4.9-10

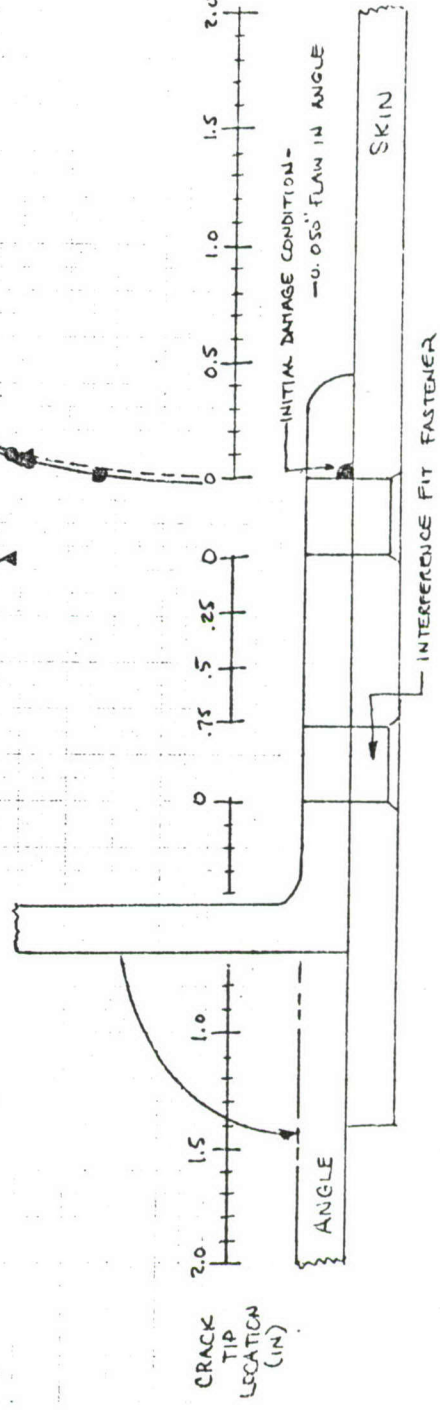
NOTE: INITIAL DAMAGE FLAWS WERE INDUCED TO BOTH THE RIGHT AND LEFT ANGLES



RIGHT ANGLE (TEST DATA)
 LEFT ANGLE (TEST DATA)
 SKIN (TEST DATA), RIGHT SIDE
 ANGLE (PREDICTION)



14558
 13300
 11024

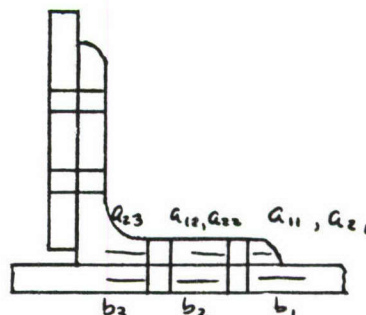


DATA SHEET NO. S: 573310-11

TEST DATE(S): 3/4/77 - 3/8/77

SPECIMEN 4.9-10

N	a_{11}	a_{12}	a_{21}	a_{22}	a_{23}	b_1	b_2	b_3
0	.048*		.064*					
6500	"DIMPLE"		"DIMPLE"					
7700	.06		.08					
8200	.09		.11	"DIMPLE"				
8400	.10		.13	.03				
10000	.17		.22	.18				
10800	.22		.34	.30				
11024	.23		TO EDGE	.45				
11400	.24			TO NEXT FASTENER				
13000	.32							
13800	TO EDGE							
26000		.26						
26301		.40						
26340		TO NEXT FASTENER						
34200						.12		
37000						.34		
39000						.66		
39500						.81		
40000						.9		
40500						1.28		
40700						1.54 ¹		
45118							TO NEXT FASTENER	.64
45123								TO EDGE
45220					.50			
45924	F	A	I	L	U	R	E	

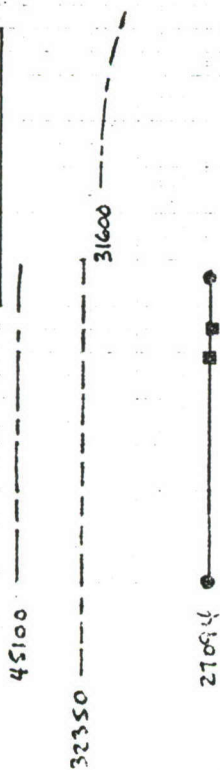


DATA IDENTIFICATION

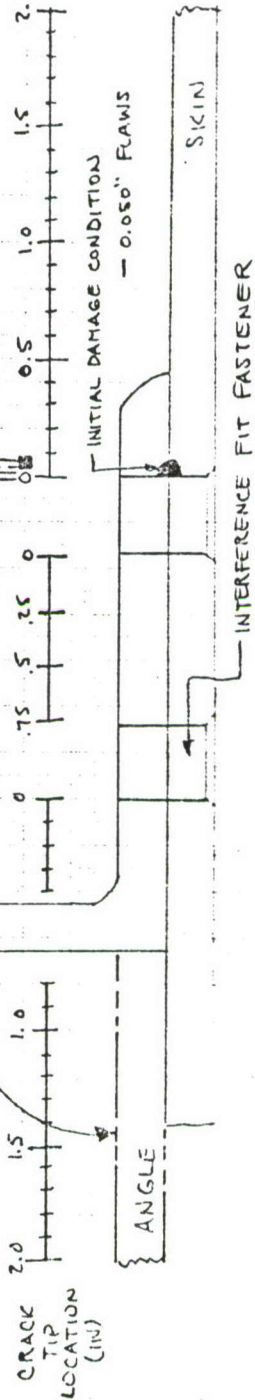
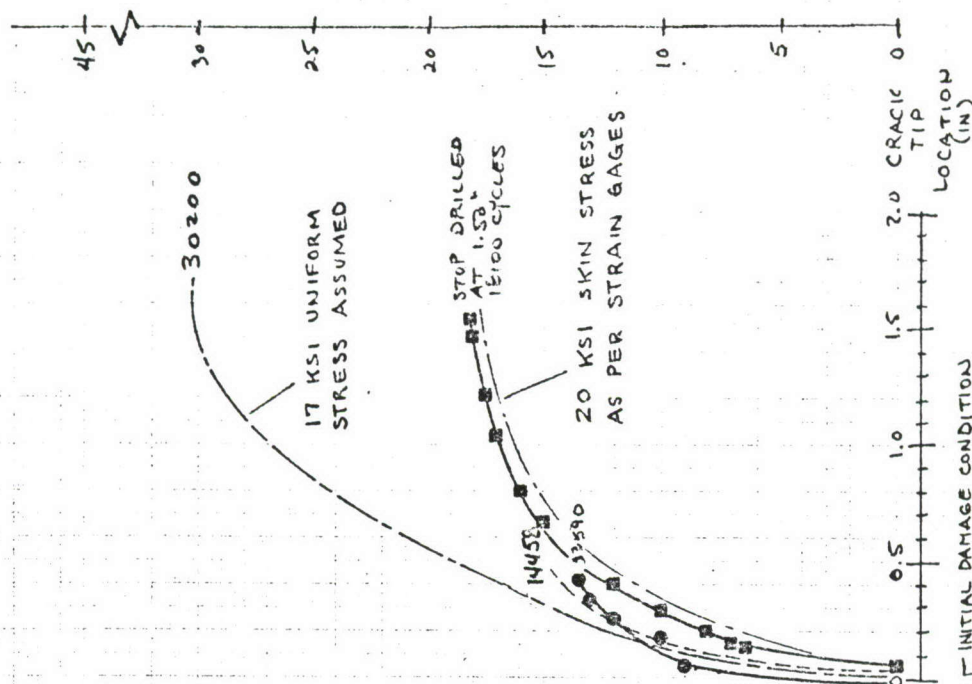
- NOTES:** THE NOTATION USED TO DESCRIBE THE CRACK POSITION IN THE SKETCH ABOVE HAS BEEN SLIGHTLY ALTERED TO ALLOW FOR GROWTH IN THE ANGLE MEMBER ON BOTH THE RIGHT AND LEFT SIDES. THE NOTATION a_{1n} REFERS TO THE LEFT SIDE AND a_{2n} TO THE RIGHT
- * THE MEASUREMENTS REFER TO THE MANUFACTURED INITIAL CORNER FLAW. SUBSEQUENT MEASUREMENTS ARE FOR CRACKLENGTHS AS VIEWED FROM THE SURFACE.
- ¹ THE CRACK TIP WAS STOP-DRILLED AT 1.53"
- ² THE CRACK GREW UP THE OUTSTANDING LEG AND ARRESTED AT THE FIRST FASTENER CONNECTING THE LEG TO THE WEB

UNITED STATES GOVERNMENT

SPECIMEN 4Q-11



THOUSANDS OF CYCLES

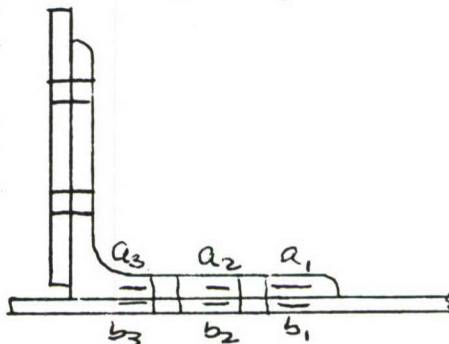


DATA SHEET NO.S: 573312-13

TEST DATES: 3/8/77 - 3/10/77

SPECIMEN 4.9-11

N	a ₁	a ₂	a ₃	b ₁	b ₂	b ₃			
0	.047*			.079*					
6500	—			.14					
7000	—			.16					
8000	"DIMPLE"			.20					
8600	.03			.24					
9000	.05			.25					
10000	.17			.29					
12000	.25			.40					
13000	.33			.45					
13500	.42			.49					
13590	TO EDGE			—					
14000				.52					
15000				.65					
16000				.80					
16500				.92					
17000				1.04					
17500				1.21					
18000				1.46					
18100				1.53 ¹					
19100		.04							
19600		.14							
20000		.22							
20300		.36							
20341		TO NEXT FASTENER							
26831			.08			.30			
26847			.11			.57			
26863			.32			.63			
26869			.52			TO EDGE			
26912			.90						
26933			1.98						
27094	F	A	I	L	U	R	E		



DATA IDENTIFICATION

NOTES* THESE MEASUREMENTS ARE FOR THE MANUFACTURED
INITIAL CORNER FLAW. SUBSEQUENT MEASUREMENTS
ARE FOR THE CRACK LENGTHS VIEW FROM THE SURFACE
¹ THE CRACK TIP WAS DRILLED OUT AT 1.53 IN

SPECIMEN 4.9-12

52685

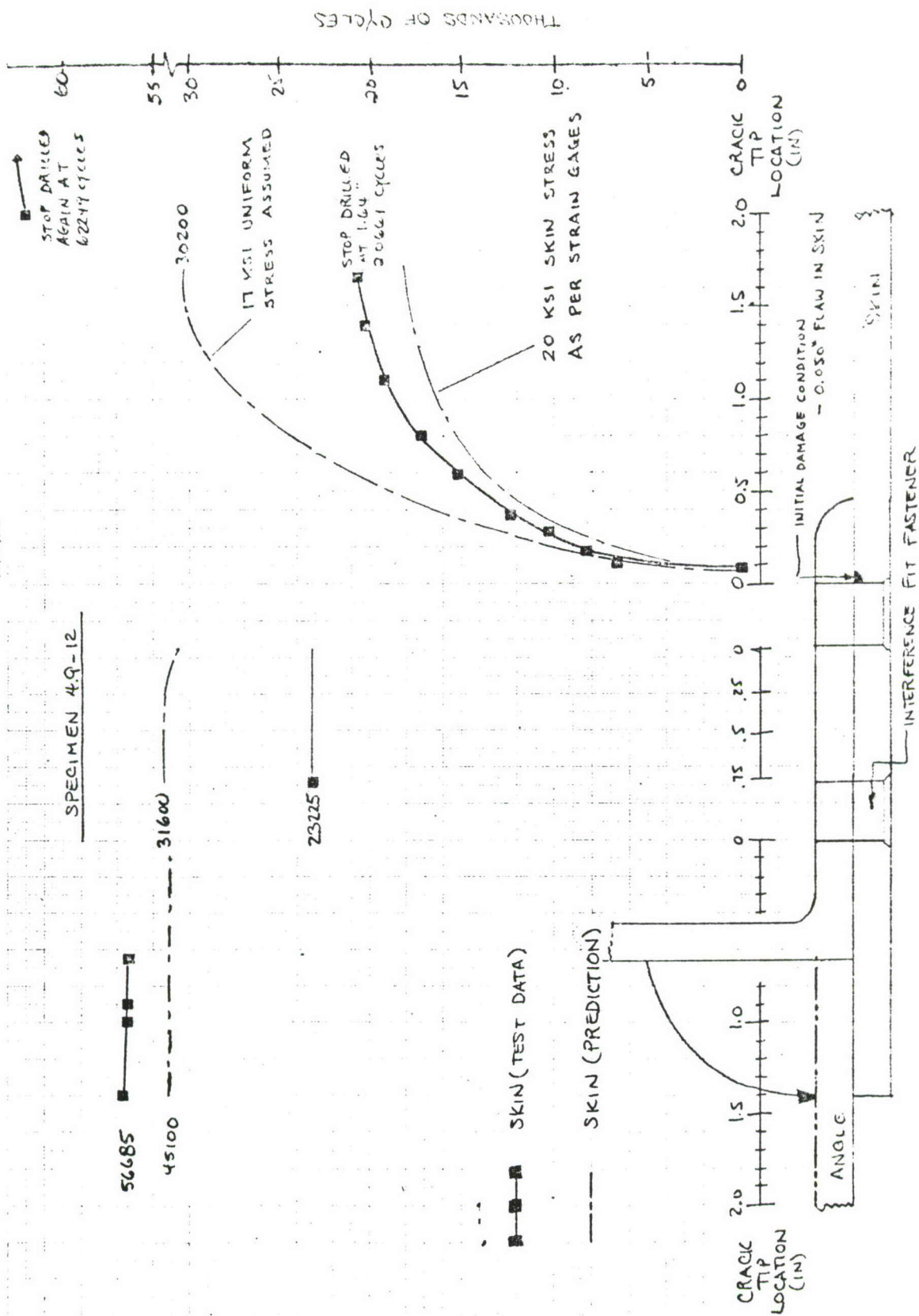
45100

31600

23225

SKIN (TEST DATA)

SKIN (PREDICTION)

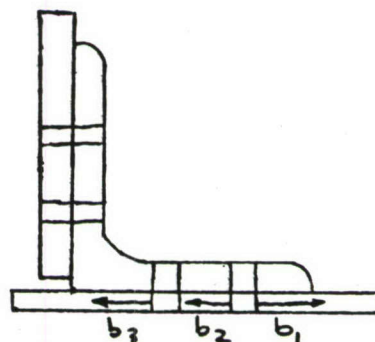


DATA SHEET NO. S: 573304-S

TEST DATE(S): 2/21/77-2/24/77

SPECIMEN 4.9-12

N	b ₁	b ₂	b ₃						
0	.058*								
2228	TEST DELAY DUE TO STUD FAILURE								
4000	-								
6741	.11								
8241	.17								
10241	.27								
12241	.37								
14241	.52								
15241	.59								
16241	.69								
17241	.80								
18241	.89								
19241	1.10								
20241	1.39								
20661	1.64 ¹								
23225		TO NEXT FASTENER							
56429			.65						
56595			.90						
56645			1.03						
56685			TO EDGE						
62000	2								
62249	3								
69204 ⁴	F	A	I	L	U	R	E		



DATA IDENTIFICATION

NOTES: * THESE MEASUREMENTS ARE FOR THE MANUFACTURED INITIAL CORNER FLAW. SUBSEQUENT MEASUREMENTS REFER TO CRACK LENGTHS AS VIEWED FROM SURFACE.

¹ THE CRACK TIP WAS STOP DRILLED

² THE CRACK REINITIATED ON THE OPPOSITE SIDE OF THE STOP DRILL. A SECOND STOP DRILL WAS PUT IN

³ THE CRACK GREW INTO THE STOP DRILL

⁴ PANEL STARTED TO CRACK AT THE TOP - RIGHT FASTENER IN THE REAR OF THE PANEL. IT IS SIGNIFICANT TO NOTE THAT THE SAME STUD DEVELOPES A CRACK DURING THE NEXT TEST (SPEC. NO. 4.9-6)

SECTION VIII
TWO-BAY SPECIMENS

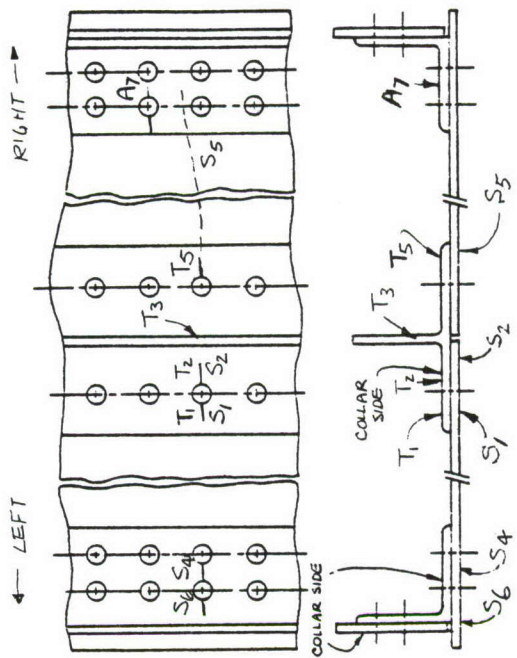
Tabulated crack growth for the four two-bay specimens are presented in this section. Specimen configurations and initial damage conditions for these specimens are shown in Figures B-3 (Appendix B) and 7 and Table 5B of Volume I. Specimens 4.10-2 and 4.10-4 were tested at $S_{\max} = 17$ ksi, $R = 0.1$. However, the other two specimens, 4.10-1 and 4.10-3, were tested at a lower stress level of $S_{\max} = 12$ ksi, $R = 0.1$.

The insert on each table shows schematically the crack path and helps in clarifying the notation describing the location of each crack. Crack lengths S_i are measured on the skin; T_i in the tee, and A_i in the angles.

NOTES FOR ALL TWO-BAY SPECIMENS

- ① Initial crack lengths measured at faying surface before assembly. All other crack length measurements are at externally-visible surfaces.
- ② Marking cycles were at $S_{\max} = 17.0$ ksi, $R = 0.82$. Numbers in parentheses indicate numbers of marking cycles applied.
- ③ Crack extended to edge of the tee, angle, or skin member.
- ④ Crack reached radius at base of the vertical flange of tee (or angle) member.
- ⑤ Crack T_2 reappeared on other side of the vertical flange of tee member. Crack lengths measured from scribe mark.
- ⑥ Crack extended into the vertical flange of tee (or angle) member. Crack lengths measured from scribe mark.
- ⑦ Crack T_2 extended to fastener hole.
- ⑧ Failure of the vertical flange of tee (or angle) member.
- ⑨ Complete failure of the tee member.
- ⑩ Crack extended from fastener hole to fastener hole.
- ⑪ Complete failure of the right-side skin
- ⑫ Complete failure of the left-side skin
- ⑬ Complete failure of the right-side angle member.
- ⑭ Strain survey
- ⑮ Complete failure of the right-side angle member.
- ⑯ Complete failure of the left-side angle member.

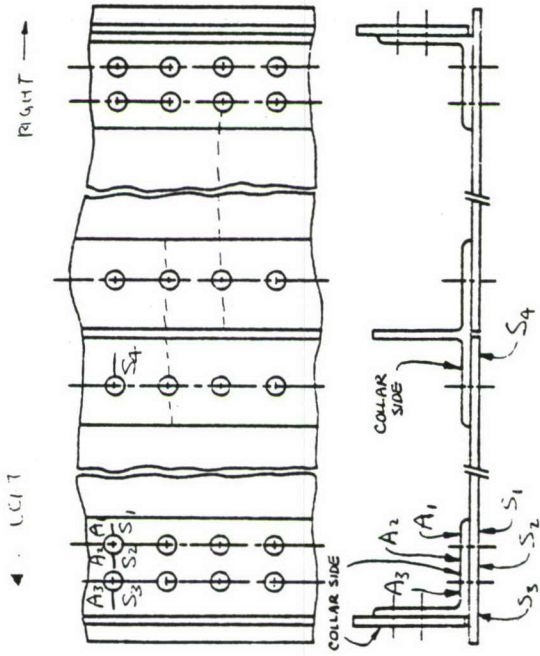
SPECIMEN 4.10-1		DATA SHEETS : 573328-31		TEST DATE(S) : 5-5-77 TO 5-11-77	
N	T ₁	S ₁	T ₂	T ₃	S ₂
15200	0.120①				
(10000)	MARKING		CYCLES A ②		
16200	0.140				
18200	0.190				
20200	0.240	0.07			
(10000)	MARKING		CYCLES B		
22200	0.270	0.11			
24200	0.320	0.15			
26200	0.370	0.19			
27190	③	—			
27200		0.21			
30200		0.30			
(10000)④	MARKING		CYCLES C		
35200		0.44			
40200		0.62			
55200		0.86			
(10000)	MARKING		CYCLES D		
56200		0.92	0.110		
57200④		1.0	0.260		
60200		1.14	④		
60700		1.20			
(10000)	MARKING		CYCLES E		
61200④		1.30			
62700		1.42			
65200		1.70			
65600		1.73	0.08⑤	0.39⑥	
66000		1.82	0.22⑤	0.49	③
66300④		1.94	⑦	0.55	
66900		2.40		0.71	
67100		2.54		0.97	
67500		3.04		1.49	
				1.79	
(TO BE CONTINUED)					



N	T ₁	S ₁	T ₂	T ₃	T ₅	S ₄	P ₅	P ₆	A ₇
67500	(3)	3.04	(7)	1.50					
68200		4.20		(8)					
68400		4.68			0.10				
68450		4.90			(9)				
68500		(10)							
69000									
(10000)			MARKING CYCLES F						
74000						(10)			
74150							1.10		
74200							5.0		
75095							(11) NO CRACK APPEARED AT FASTENING HOLES		
75700							0.14		
75800							0.60		
75811							(12)		
76918									(13)
76932			FAILURE OF PANEL-						

SPECIMEN 4.10-3 DATA SHEET(S): 573333 - 2.5 TEST DATE(S): 5-13-77

N	A ₁	Δ ₁	Δ ₂	A ₂
11500	DIMPLE			
13000	0.08(1)			
15000	0.14			
(10000)	MARKING			CYCLES A(2)
16000	0.18	0.04		
18000	0.24	0.17		
20000	0.32	0.21		
22000	0.44	0.25		
22830	(E)	---		
(10000)(19)	MARKING			CYCLES B
24000		0.36		
26000		0.42		
28000		0.52		
30000		0.56		
33000		0.61		
(10000)	MARKING			CYCLES C
36000		0.78		
39000		0.92		
42000		1.07		
45000		1.24		
48000		1.46		
(10000)	MARKING			CYCLES D
49000		1.60		
52000(19)		1.96		
54000		2.32		
55000		2.70	(10)	0.04
55200		2.80		0.20
55300		2.92		0.30
55500		3.04		(10)
56000		3.60		
56800		(10)		
(TO BE CONTINUED)				

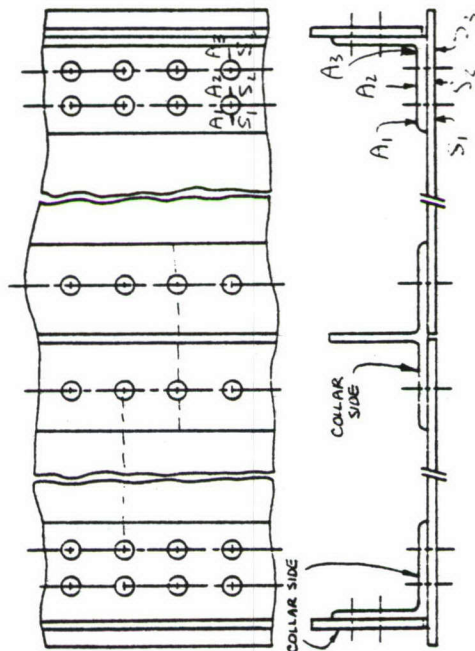


SPECIMEN 4.10-3 (CONTINUED)									
N	A ₁	S ₁	S ₂	A ₂	S ₃	A ₃	S ₄		
56800	(3)	(10)	(10)	(10)	(3)	(4) (6)			
57925						1.30			
—						(10)	(12)		
58000									
58200									
58834									
58900									
		FAILURE OF PANEL							
		NOTE THAT FAILURE OF THE LEFT-SIDE SKIN,							
		THE TIE, AND THE RIGHT-SIDE SKIN MEMBERS,							
		DID NOT OCCUR ALONG THE SAME FASTENER ROW.							
		SEE THE INSERTED SKETCH ON THE PREVIOUS							
		PAGE.							

LOCKHEED AIRCRAFT CORPORATION

SPECIMEN 4-10-4 DATA SHEET(S): S73340-13 TEST DATE(S): 5-25-77

N	S ₁	A ₁	A ₂	S ₂	A ₃	S ₃
6000	0.11					
7000	0.17	DIMPLE				
7500	0.21	0.08				
8000	0.24	0.12				
(10000)		MARKING CYCLES A (2)				
8500	0.28	0.17				
9500	0.34	0.22				
10500	0.41	0.32				
11000	0.44	0.46				
11100	—	(3)				
13000	0.59	MARKING CYCLES B				
(10000)						
14000	0.74					
16000	1.10	DIMPLE				
16100	1.14	0.11				
16200	1.18	0.28				
16280	1.22	(10)				
16500	1.34					
16900	1.79					
17200	2.44					
17333	3.52			(10)		
17342	(10)				0.18	
17813					(10)	(3)
17829						
17885						
FAILURE OF PANEL						
NOTE THAT FAILURE OF THE ANGLE,						
THE TEE AND THE SKIN MEMBERS						
DID NOT OCCUR AT THE SAME FASTENER						
ROW.						



SECTION IX
SPECIMEN PRECRACKING DATA

Section VI of Volume I discusses the precracking of the component pieces of each structural specimen. The following tables summarize the records that were kept of precrack sizes and final crack growth rates during precracking. It was believed to be important to keep the final precrack growth rate equal to or slower than the initial crack growth rate in the test to avoid crude retardation effects.

It was generally attempted to keep the initial crack size between 0.040 and 0.060 inch and the final precrack growth rate below 10^{-5} inch per cycle. Some pieces were precracked outside these limits, but in none of the specimens involved did the precracking seem to significantly affect any aspect of the test results.

PRECRACK DATA - DOUBLE LAP JOINTS

Specimen Number	Initial Crack, a_i (Inches)			Max $\frac{da}{dN}$ during precrack: (microin./cyc.)		
	Doubler S1	Skin	Doubler S2	Doubler S1	Skin	Doubler S2
4.6A-1	0.046	0.049	0.047	8.3	9.0	1.5
4.6A-2	0.047	0.044	0.052	12.5	10.0	9.0
4.6A-3	0.047	0.050	0.048	5.0	10.0	8.5
4.6A-4	0.050	0.050	0.049	7.0	3.0	40.0
4.6A-5	0.045	0.057	0.048	30.0	12.5	25.0
4.6A-6	0.043	0.049	0.048	7.5	4.0	6.3
4.6A-7	0.044	--	--	10.0	--	--
4.6A-8	0.046	--	--	4.2	--	--
4.6A-9	0.049	--	0.052	23.0	--	25.0
4.6A-10	0.040	--	0.042	24.0	--	9.0
4.6B-1	0.047	0.057	0.046	7.0	5.0	4.0
4.6B-2	0.054	0.057	0.057	4.0	10.0	2.5
4.6B-3	0.053	0.042	0.051	4.0	4.0	7.0
4.6B-4	0.047	--	--	2.5	--	--

PRECRACK DATA - SINGLE LAP JOINTS

Specimen Number	a_i , (inch)		Precrack da/dN (microinch/cycle)	
	Skin	Doubler	Skin	Doubler
4.7-1	0.041	0.058	7.0	4.0
4.7-2	0.050	0.051	6.2	9.0
4.7-3	0.048	0.050	12.0	10.0
4.7-4	0.049	0.049	7.0	6.6
4.7-5	0.042	0.032	11.0	10.0
4.7-6	0.044	--	5.0	--
4.7-7	0.057	--	35.0	--
4.7-8	0.080	--	25.0	--
4.7-10	0.051	--	7.0	--
4.7-11	0.064	--	10.0	--
4.7-12	0.049	--	10.0	--
4.7-13	0.049	--	8.0	--

PRECRACK DATA - CONTINUOUS-SKIN TEE

Specimen Number	a_i , (inch)		(da/dN) max microinch/cycle	
	Tee	Skin	Tee	Skin
4.8-1-1	0.050	0.060	10.0	7.1
4.8-1-2	0.054	0.055	12.0	10.0
4.8-1-3	0.050	0.054	3.0	12.0
4.8-1-4	0.084	0.075	3.0	11.0
4.8-1-5	0.058	0.046	10.0	15.0
4.8-1-6	0.064	--	3.0	--
4.8-1-7	0.062	0.049	13.0	15.0
4.8-1-8	0.056	0.050	15.0	12.0
4.8-1-9	0.055	0.052	5.0	32.0
4.8-1-10	0.028	0.042	10.0	5.0
4.8-1-11	0.062	0.055	5.0	10.0
4.8-1-12	--	0.062	--	30.0

PRECRACK DATA - SPLIT SKIN TEE AND TWO-BAY

Specimen Number	a_i , (inch)		Precrack da/dN (microinch/cycle)	
	Tee	Skin	Tee	Skin
4.8-3-1	0.050	0.041	9.3	1.0
4.8-3-2	0.046	0.045	16.0	23.0
4.8-3-3	0.066	0.052	9.0	24.0
4.8-3-4	0.042	0.037	27.0	30.0
4.8-3-5	0.047	0.040	21.0	31.0
4.8-3-6	0.059	--	9.3	--
4.8-3-7	0.061	0.059	32.0	15.0
4.8-3-8	0.046	0.073	32.0	17.0
4.8-3-9	0.050	0.043	5.0	16.0
4.8-3-10	0.055	0.050	3.5	50.0
4.8-3-11	0.056	0.048	4.2	25.0
4.8-3-12	--	0.052	--	33.0
4.8-3-13	0.045	0.037	7.0	10.0
4.8-3-14	0.051	0.043	8.0	6.0
4.10-1	0.048	0.047	6.5	10.0
4.10-2	0.058	0.045	9.3	9.0

PRECRACK DATA - EDGE STRINGER AND TWO-BAY

Specimen Number	a_i , (inch)		Precrack (da/dN) (microinch/cycle)	
	Angle	Skin	Angle	Skin
4.9-1	0.029	0.060		
4.9-2	0.041	0.050		
4.9-3	0.053	0.065		
4.9-4	--	0.056		
4.9-5	0.050	0.051		
4.9-6	0.058/ 0.082	--		
4.9-7	0.048	0.052	NOT RECORDED	NOT RECORDED
4.9-8	0.051	0.050		
4.9-9	0.070	0.073		
4.9-10	0.048/ 0.064	--		
4.9-11	0.047	0.079		
4.9-12	--	0.058		
4.10-3	0.057	0.060	7.6	8.0
4.10-4	0.055	0.069	4.0	7.0